

**REPORT OF THE
CLIMATE DATA MANAGEMENT WORKSHOP**

SPONSORED BY:

THE NATIONAL CLIMATE PROGRAM OFFICE

AND

**THE ENVIRONMENTAL DATA AND INFORMATION SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION**



**CLIFFSIDE MOTOR INN
HARPERS FERRY, WEST VIRGINIA
MAY 8-11, 1979**



CLIMATE DATA MANAGEMENT WORKSHOP

May 8-11, 1979


Cliffside Motor Inn
Harpers Ferry, West Virginia

United States Department of Commerce
Juanita M. Kreps, Secretary

National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator

National Climate Program Office
Edward S. Epstein, Director

Environmental Data and Information Service
Thomas D. Potter, Acting Director



Digitized by the Internet Archive
in 2012 with funding from
LYRASIS Members and Sloan Foundation

<http://www.archive.org/details/reportofclimated00clim>

EXECUTIVE SUMMARY

The National Climate Program Act (PL 95-367), as the enabling legislation, sets out the basic policy for this Program. Among its findings pursuant to the Act, Congress declared that: "Information regarding climate is not being fully disseminated or used, and Federal efforts having given insufficient attention to assessing and applying this information." The Congress further found that: "The United States lacks a well-defined and coordinated program in climate-related research, monitoring, assessment of effects, and information utilization". Thus, the Act mandates that, among other elements, the Climate Program contain:

- "Global data collection and monitoring and analysis activities to provide reliable, useful and readily available information on a continuing basis.
- "Systems for the management and active dissemination of climatological data, information and assessments, including mechanisms for consultation with current and potential users.
- "Measures for international cooperation in climate research, monitoring, analysis, and data dissemination."

In the spirit of the Act and in the interest of developing an effective, comprehensive program to serve the Nation's needs for climate information, a Workshop was held to bring together a broad range of climate data specialists -- both data managers and data users. The goals of the Workshop were:

1. To further the development of an integrated inventory of climate data.
2. To make preliminary assessments of the status of the various types of climate data in relation to requirements.
3. To outline steps/efforts to enhance accessibility and utility of climate data.
4. To recommend steps to be taken after the Workshop to further progress toward a national inventory.

The primary effort of the Workshop took place in Working Groups organized as follows:

1. Basic Atmospheric Data
Co-Chairmen: Robert J. Fox
Gordon A. McKay
2. Hydrology, Precipitation, Snow and Ice
Chairman: Eugene Rasmusson
3. Ocean Data
Chairman: Kent Hughes
4. Radiation, Physics, and Chemistry
Co-Chairmen: Albert Arking
Otto Thiele
5. Proxy and Non-Instrumental Data Resources
Co-Chairmen: Alan Hecht
George Smith
6. Geographical, Land Use, and Assessments Data
Chairman: James R. Anderson
7. Climate Inventory
Chairman: Kenneth Hadeen

The Reports of the Working Groups form the core of this Workshop Report.

The following summarizes certain of the recommendations which were common to several Working Groups. Analyses, justification, and further amplification as well as additional specific recommendations are in the Working Group Reports. This summary presents the recommendations in relation to the goals of the Workshop.

SUMMARY RECOMMENDATIONS

I. Regarding an Inventory of Climate Data

Existing data must be identified, described, and its presence and utility made known to the user community.

--Data set identification must be continued and expanded to include State and private sources;

--A permanent mechanism must be established for coordination, evaluation, publication, and update of the inventory.

Specifically, it is recommended that NAWDEX be expanded to an international inventory and exchange system for streamflow and groundwater information; and that WATSTORE be expanded into an archive for such information.

This recommendation, along with the earlier plan (Ref. 1) to incorporate all appropriate data files into NOAA's Environmental Data Index (ENDEX) sets a clear framework for progress toward a complementary inventory system. The Report of Working Group 7 lays out further guidelines toward an inventory.

II. Regarding Assessments of the Status of Data in Relation to Requirements

These assessments are analytical in nature and peculiar to each data regime. Please refer to the Working Group Reports for the assessments.

III. A. Regarding Steps and Efforts to Enhance Accessibility of Climate Data

1. Noting the continued growth in user requests and the need for timely response, agencies and repositories should prepare readily available sets of basic data which are in high demand based on experience with users' request. Data set preparation should include improvements in quality, ease of access, and completeness of the data files for both existing data and those to be archived in the future.

2. In view of the scarcity of Data Management resources (manpower and budget) and the potentially large demand upon them, an objective, program-wide, coordinated system must be developed to prioritize the compilation of data sets. Net social benefit, feasibility, costs, and utility of the data set should be factors that determine priorities between data management development and services. For instance, passive microwave data from the NIMBUS satellite series has great promise of yielding a global picture of precipitation -- especially over the oceans. However, systematic efforts to compile, reduce, and publish the full set of data should await further results on the accuracy, interpretation, and reliability of the data. In view of the great potential value of the data set, verification tests and analyses should proceed immediately.

3. Operational programs (e.g., weather and river flow forecast) are sources of vitally important data for Climate Program purposes. It is recommended that:

- a. Operational data products (both input data and the results of analyses) be reviewed as soon as possible to ensure that all data valuable for climate purposes are saved.

- b. Agencies take steps to document changes in operational data analysis procedures as such changes have great impacts on the analyses of the data record for climate purposes.
- c. Enough input data be saved to permit new analyses, using uniform methods, in order to resolve problems that are important enough to justify the expense of re-analysis.

These requirements should be made known to operational data acquisition and analysis elements in a systematic and well coordinated way. For example, the Climate Analysis Center in NOAA could be the appropriate interface for communicating Climate Program interests to operational elements such as the National Meteorological Center and the Office of Hydrology. Additional interfaces need to be identified for other major data analysis activities such as in DOD, USDA, USGS, and so forth.

B. Regarding Steps to Increase the Usefulness and Use of Climate Data

1. Data must be acquired and records maintained in the most complete and comprehensive manner practicable. Improvements in this area will require United States efforts at the local, national, and international levels.

- a. The maintenance of a valid climatic record must include accurate station histories particularly regarding changes in and calibration of instrumentation and changes in the physical surroundings of the measurement site.
- b. As data are collected by a variety of agencies and institutions, there is a clear need to develop and observe uniform standards for station inspection and calibration.
- c. The United States must actively cooperate and promote quality, conformity and completeness in the acquisition of climatic information on a global basis. This will include active support of programs leading to receipt of quality conventional, climatological and upper air observations not presently being obtained on a scheduled basis by the United States. Vigorous support must also be given to WMO efforts to enhance data reported and its timely receipt such as by new codes and message content standards.

2. Because of the high cost of retrofit and the possible loss to the user community of valuable information, the Data Management objectives and requirements of the National Climate Program must be incorporated into the planning and budgeting for new observation systems and the modification of existing systems.

- a. Because new observation systems such as the National Oceanic Satellite System (NOSS) and System 85 will be important sources of climate data, effective mechanisms must be developed to acquire the data.
- b. Economically important user programs may be greatly disadvantaged by inadvertent changes in the data acquisition and data management system. Due consideration must be given to such impacts which may be counter to National Climate Program objectives.

Specifically, there should be a thorough study to define objective requirements for climatic measurement networks as a firm basis for maintaining and supporting them. Such a study should include data requirements for assessments, applications and research; measurements should include both basic atmospheric and hydrologic data needs.

3. The information and service requirements of current and potential users must be clearly defined as a basis for further development of responsive data management and dissemination programs.

- a. The user community (Federal, State, academic, private) must be defined in terms of their needs for information and the most appropriate means of access. A first step should be the systematic consolidation and evaluation of the results of the several previous conferences to identify those needs and means of access.
- b. There should also be joint efforts, with users, to exploit historical data resident in the archives but not presently reduced to climatic parameters or accessible through the system.

4. As part of their information services program, agencies and other data repositories should increase their efforts to inform user communities of the availability, means of access to, and ways of applying climate data and information. This requires:

- a. Instruction and information on the optimal use of the system in the form of handbooks, handouts, and active user assistance programs, and
- b. Promotion, such as by articles in trade journals, user workshops, and speakers at technical meetings of potential user communities.

IV. Regarding Steps to be Taken After the Workshop to Further Progress Toward an Inventory and Other Goals of the Workshop

The preceding recommendations have implications for all suppliers and users of data management services considered within the National Climate Program.

1. The National Climate Program Office

The Act establishes the National Climate Program Office (NCPO) as the lead entity for administering the Program. This was done in the context of formulating a well-defined, coordinated National Program from the several Federal and State activities which have been underway. Thus, the NCPO can and should serve as a catalyst in bringing together appropriate parties and stimulating action to move the Program along. The Office is the logical central agent to act as an advocate for the recommendations presented here and see that they are respected in reports, plans, and budgets relative to the Climate Act and Program.

Specifically, the NCPO should:

- a. Formalize the Workshop's climate data inventory project. A first step should be the final preparation and publication of the data inventory gathered in preparation for the Workshop.
- b. Advocate, promote, and where possible support activities -- including studies -- directed toward improved data acquisition, archival, and dissemination and user service programs. Internationally, this may entail working through the State Department and lead agencies which normally interface with international bodies (e.g., NOAA with WMO).

- c. Take the initiative to establish coordination of interagency, intergovernmental, and public/private activities as required to implement these recommendations.

2. Other Federal Agencies/Departments

Implementation resides mainly with operating agencies. The NCP Act requires that each Federal officer, employee, department, and agency involved in the Program shall cooperate with the Secretary of Commerce in carrying out its provisions. The cooperating agencies have, therefore, the responsibility to develop appropriate data management systems, having an accountability extending from acquisition to delivery for data within their jurisdiction. All the preceding recommendations have relevance to these agencies. Furthermore, interagency action is essential in the development of the most appropriate user oriented data base and information delivery systems.

Specifically, the cooperating agencies and departments should:

- a. Identify, describe, and make known their holdings of climatic and climate related data/information;
- b. Clearly define the needs of their current and potential user community;
- c. Develop methods for prioritizing services on the basis of net benefit to the Nation, feasibility, and resources required.
- d. Improve the quality and content of their data holdings and enhance their utility by incorporating station history and geographic data;
- e. Publicize their holdings and their utility and provide active user assistance;
- f. Cooperate with WMO and other international agencies for the acquisition of complete, timely, and quality data on a global basis;
- g. Incorporate data management considerations in major new data systems or alterations thereto.

3. Intergovernmental

Since State and inter-State climate programs are an integral component of the Act, they too must be developed consistent with the NCP data management requirements. Contracts, grants, and other support must be negotiated with due recognition for data management objectives. State data management systems should be operated as components of a hierarchal national data management system.

4. Private Sector, Universities, Insitutions

Most of the beneficiaries of the NCP Act are within this group. Tailoring of the appropriate data management system requires extensive user involvement in the definition of needs, system planning, and redesign. Furthermore, members of this group operate special data systems which should be included within the National Program. Mechanisms must be developed for their close involvement, possibly through professional and technical organizations that speak on their behalf.

PREFACE

In some ways, this Workshop was "an idea whose time had come." First, the need for improved access to climate data had been noted by the Climate Research Board of the National Academy of Sciences. Their review (NAS 1979) of agency planning for the National Climate Program cited the need for "a unified though not necessarily centralized data archive." This need was noted in the context of growing user demand for comprehensive and complementary sets of data, portions of which may be housed among several institutional structures. Second, leading climatologists, such as Professor Helmut Landsberg, had been calling for a comprehensive inventory of climate data holdings -- especially in the context of upgrading the quality and coverage of the data. Third, the U.S. Climate Program Plan (NOAA 1977) called for "a significant initiative to plan a major expansion of activities to locate, inventory, and index climate data." The plan specifically called for incorporation of all appropriate U.S. data files into NOAA's ENDEX system and the interfacing of ENDEX with international data indexes such as UNEP/IRS and IODE/MEDI. Subsequently, the NOAA Climate Program (NOAA 1977) called for implementation of these aspects of the National Plan. Then finally, the National Climate Program Act (Public Law 95-367, 1978) established a program element for "global data collection, and monitoring and analysis activities to provide reliable, useful, and readily available information on a continuing basis."

Thus, in September of 1978, just after the signing of the Climate Program Act, the National Climate Program Office (NCPO) and NOAA's Environmental Data and Information Service jointly called together representatives of agencies participating in the National Climate Program, to plan a Data Management Workshop. The goals established for the Workshop were:

1. To further development of an integrated inventory of climate data.
2. To make preliminary assessments of the status of the various types of climate data in relation to requirements.
3. To outline steps/efforts to enhance accessibility and utility of climate data.
4. To recommend steps to be taken after the Workshop to further progress toward a national inventory.

In considering the conduct of the Workshop, two points bear special notice: First, the question of "requirements" arose time and time again. The bases of the Workshop were that (a) many statements of requirements were already in existence and that (b) a comprehensive reformulation of requirements would call for a Workshop or forum of its own. This Workshop

was therefore to focus on the solution of problems associated with the data, per se, in the context of present requirements. Second, some of the recommendations relate to measurement activities and to information services. While these areas are strictly distinct from data management, the data managers are aware of gaps in the data record which limit the use and degrade the reliability of the record. The data managers also know how to improve the interface with users (the Services Program), for they are often the final recipients of user requests for data and information.

Because of the breadth of climatic data among geophysical regimes, the Workshop adopted a Working Group structure basically along the lines of the regimes. Further, the Working Groups themselves were composed of discipline area specialists (both data managers and users) within the regimes. The main efforts in achieving the goals of the Workshop were to be the special studies done by Working Group members in advance of the Workshop and the preparation of Working Group Reports at the conference itself.

A final word on the data set information sheets. In pursuit of goals relating to the inventory, we collected over 900 data sheets describing existing climatic data sets and certain other data useful in climatic assessments. The original plan was to review, edit, and publish this collection as an appendix to the Proceedings. However, the review and editing task was too extensive to be completed in time for these Proceedings. The data sheets do form a solid first core of inventory information which can serve as the basis for the inventory project the Workshop recommended.

Dudley G. McConnell, Associate Director
Data Information Services
National Climate Program Office
National Oceanic and Atmospheric
Administration

REFERENCES

- Interdepartmental Committee for Atmospheric Sciences (ICAS), 1977: A United States Climate Program Plan. Federal Council for Science, Engineering, and Technology, July.
- ICAS, 1977: A United States Climate Program Plan by a drafting group of the Interdepartmental Committee for Atmospheric Sciences (ICAS), Federal Council for Science, Engineering, and Technology, July 1977. Available from the National Climate Program Office, NOAA Headquarters, Rockville, MD 20852.
- NAS, 1979: Toward a U.S. Climate Program. Report of the Workshop to Review the U.S. Climate Program Plans. 1979. Available from the Climate Research Board, National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418.
- NOAA, 1977: NOAA Climate Program. NOAA. December, 1977. Available from the NOAA Climate Program Office, NOAA Headquarters, Rockville, MD 20852
- Public Law 95-367, 1978: The National Climate Program Act, Sept. 17, 1978. 15 USC 2901 through 2908.

ACKNOWLEDGEMENTS

As Chairman of the Workshop, I wish to express my deep and sincere gratitude for the devoted effort of the Workshop participants. Many traveled great distances and withstood troublesome inconveniences to be a part of the effort. In that same spirit of cooperation and constructive contribution, the Working Group Chairmen deserve special appreciation. They all, individually, have important and demanding professional responsibilities. Yet, since the time they were named (January 1979), they have given hour upon hour of intense, productive attention to the tasks of the Workshop. Truly, the output of the Working Groups is the substance of the Workshop and the body of this Report.

I want especially to thank Ernest Neil, Director of the Meteorological Program Office at NASA's Goddard Space Flight Center, for his expert guidance and counsel in administering the Workshop. And finally, I wish to thank Susan Orchin, Suzanne Karam, and Mildred Blackwell, of the Systematics General Corporation. They served as Conference Manager, Conference Coordinator, and Clerical Staff Supervisor, respectively. Their efforts were vital to a productive, smoothly run, effective Workshop.

Dudley G. McConnell
Chairman

CONTENTS

	<u>Page</u>
Executive Summary.	iii
Preface.	xi
Acknowledgements	xiv

I. WORKING GROUP REPORTS

Basic Atmospheric Data	
Working Group 1.	1
Hydrology, Precipitation, Snow and Ice	
Working Group 2.	11
Ocean Data	
Working Group 3.	57
Radiation, Physics, and Chemistry	
Working Group 4.	77
Proxy and Non-Instrumental Data Resources	
Working Group 5.	115
Geographical, Land Use, and Assessment Data	
Working Group 6.	127
Climate Inventory	
Working Group 7.	159

II. SPECIAL TOPICS

Open Letter to the U.S. Department of Agriculture - Kenneth D. Hadeen.	173
Open Letter to the Department of Defense - Roy L. Jenne	175
Disposition of Data Inventory Information - Dudley G. McConnell.	177
Research Strategy for the U.S. Climate Program - John E. Kutzbach	179

CONTENTS (Continued)

III. WORKSHOP PROCEEDINGS

List of Participants and Observers.	187
Agenda.	193
Welcoming Address - Edward S. Epstein	195
Opening Address - Thomas S. Austin	199
National Climatic Center Current Status and Future Plans - Daniel B. Mitchell	205
Data Requirements for Research and Ways to Promote The Use of Climate Data - Roy L. Jenne.	225

AGENCY STATEMENTS

The United States Department of Agriculture - "Requirements for Weather (and Climate) Data, Service and Information" - Galen F. Hart.	239
The United States Department of Commerce - "Uses and Sources of Climate Data and Information in the Department of Commerce" - Joshua Z. Holland.	257
The United States Department of Defense - USAF - Environmental Technical Applications Center Elbert W. Friday.	269
The United States Department of Energy - Harry Moses.	275
The United States Department of Interior - George I. Smith	283
"Some Remarks Concerning Climate Service Programs in the States and the Data Needs for These Programs" - Wayne L. Decker	287
"Presentation on the Survey of NASA Data on Potential Applicability to the Climate Program" - Karen W. Posey	293

FIRST GARP GLOBAL EXPERIMENT CONCEPT



FIGURE 1.

NOAA artist's rendering of measurement systems providing data during the global weather experiment. This shows a portion of the variety of data sources to be considered during the workshop.

I. WORKING GROUP REPORTS

BASIC ATMOSPHERIC DATA

Working Group 1

Co-Chairmen: Robert J. Fox
Gordon A. McKay

Members: Harold Crutcher
Amos Eddy
Richard E. Felch
James D. Laver
August L. Shumbera
Louis Westphal

INTRODUCTION

Central to the issues that led to the promulgation of the National Climate Program Act is the need for climatological data for planning and decision making in a wide spectrum of social, economic, and environmental activities. It follows that the management of basic climatological data -- its acquisition, archiving, transformation into needed information, and dissemination -- is a fundamental undertaking within the Act.

The U. S. Climate Program Plan identifies two types of users of climatic information. The major group comprises almost all sectors of the economy, including farmers, heating and ventilating engineers, water resource managers, designers, etc. This group needs climatic information in a variety of forms ranging from simple summaries of particular data to complex expressions of climatic expectations and the results of impact studies. The second group is interested in the past climate and data pertaining to physical processes relating to climatic fluctuations, i.e., that information needed for scientific research, in development of climate forecasting, and similar problems.

The requirements for climatic data by users are not always well understood. The user community is not generally well informed on what information exists and how it may be obtained and used because of deficiencies within the supply system. The result is that available data are not being adequately exploited and data base management planning falls short of national objectives. Yet major benefits are realizable now from the use of these existing data and they may be greatly increased at a very low cost. Exploitation of this relatively untapped source is a major realizable benefit within the concept of the National Climate Program.

Relevance, credibility, utility, and accessibility are four aspects of climatological data that require particular attention. Raw data are often by-products, i.e., acquired for other purposes, and they may not be the best set or in the best form to solve the problems of a specific user. Until the user requirements are adequately known and evaluated, the data manager cannot objectively set management priorities, or be expected to respond in an effective and efficient manner.

Credibility relates to representativeness, quality, and comparability. Standards must be rigorously imposed for these purposes so that the user fully understands the quality of data sets and the context in which measurements were made. Stringent quality control measures must be implemented to ensure that the data are not degraded in the observational, transmission, and processing phases. The utility of data and user confidence therein can be quickly undermined by inadequate control. Quality must be clearly identifiable, and a feedback system should exist so that the effectiveness of these measures can be evaluated.

All data have limitations; the user must be made aware of these and of ways in which he can use data most effectively. Inadequate knowledge of the reliability and representativeness of data has led to its improper use or neglect. If the objectives of the Climate Program are to be realized, guidance on the use of climatological data/information is imperative -- logically, this must be readily accessible as part of the delivery system.

Utility relates to relevance and credibility -- but more is implied. Traditionally, data have been provided as measured values, means, or similar statistics. This is often inadequate: For many decisions the data must be transformed into information, i.e., converted into values whose utility is easily recognizable and which can be used directly in decision making. This conversion is an essential function of the data management system if the objectives of the National Climate Program are to be reached.

The data/information must also be in formats and on media that make them readily understandable, convenient, and accessible to the user. A variety of techniques is required because of the diversity of needs of the user community. Although there is a shift toward computer access, microfiche and hard copy are still preferred forms for many users.

Use implies availability of the right kind and amount of data. In fact, only limited resources are available for any endeavor and the processes of climatic data acquisition, storage, retrieval, and use are no exception. Value trade-offs must be routinely made and will continue to be made relative to the quantity and type of climatic data to be acquired, and services to be provided.

Both the value system and the trade-off decision-making can and should be objective. The users must feel their needs are being fairly considered in this determination, i.e., prioritization procedures should be quantitative and perceived as impartial. Decision models or other objective techniques are needed to rationalize and optimize the value accruing to the Nation as a result of these required trade-offs. Gross national product, national objectives, quality of the environment, and health are among the many factors upon which such decisions could be made.

Whatever the value assessments and decisions, it is clear that for the foreseeable future the hard core of basic atmospheric data for climatology will be conventional weather observations -- surface, upper air, and satellite-derived thermodynamic, moisture, and wind data -- routinely collected for operational purposes and available in digital form on communication circuits. Additionally, the cooperative or otherwise operated climatological data acquisition networks which supplement the core system also need strengthening, both on a global basis and within the United States. The Federal, State, and sub-State networks constitute continuing and growing data sources of major economic value which must be recognized as an integral part of the total system. All such data should be regularly collected on a world-wide basis by the climatology system. Furthermore, this Nation must take strong positive action to improve the collection, efficiency, and quality of the basic world-wide data set for its use by United States' agencies.

Finally, the user must participate even after receiving his data; he must "close the loop" for an effective data management system. Feedback to the data-providing agency on data relevancy and adequacy provides the basis for future enhancements of the overall system.

RESPONDING TO SOCIO-ECONOMIC NEEDS FOR DATA

Basic atmospheric data are widely used directly or in conjunction with other geophysical and social information. Present inventories show that the available data are extensive. The value of making full use of these data can be readily demonstrated. Some major sectors of use are agriculture, energy, water resources, transportation, land-use, health, fisheries, and recreation. These sectors are interested in time scales ranging from short, for operations, to long for strategic planning. Their requirements often differ from those of the weather services system in that there is a great need for site-specific information, risk statistics, packaged data, and transfer functions that relate data to economical, physical, environmental, health, and other parameters. Another major use within the Climate Program is the

support of monitoring, prediction, and research. Typical uses are in model development, diagnostic studies, and impact assessment. The need for data exists on regional to global scales, and for elements or parameters that identify with physical processes, e.g., cloud cover, temperature, and wind.

The data management issues identified in this report are considered in a generalized manner because of the diversity of users and applications. Three specific aspects considered here are: (1) data needs, (2) improving the data management system, and (3) availability of and access to data. For each of these aspects problems are identified, principles are enunciated and, finally, remedial actions are proposed. The report ends with a list of recommendations that follow from the deficiency and action stations.

DATA NEEDS

Problems

Requirements for climatological information are not always understood by data users or managers. Furthermore, not all segments of the user community are well informed on what information exists and how to obtain it.

The needs of most users are for site-specific information, i.e., detail that is often not contained in national archives. Urbanization, environmental assessment, and more effective use of natural resources is increasing the demand for such information. Estimation techniques are a logical partial solution to the expanding demand for new information, but enhanced observing networks are required for their development as well. Definition of this need and response are often effected best on the regional to local level. Mechanisms for this are presently obscure and not commensurate with needs. But site-specific information is not the only requirement. Climatological analyses and impact assessment on the regional to global scale are now of extreme importance to governments, industry, and in research. Research needs can only be adequately defined by the research community, an activity which is fairly advanced as a result of national and international experiments and climate programs.

Principles

The full spectrum of user needs must be defined, and mechanisms for providing information must be developed. This should be done in full consultation between the user community and agencies which serve their interests, and should be implemented in a way that is most cost effective, on a priority basis. The resulting system must be responsive to the need for relevant, timely information, the limitations of which are clearly understood. Major social and economic issues within a region or nation will have highest priority in the development of the climatic information system.

Remedial Actions

Remedial actions include the development within service agencies of needs-oriented, product-generating systems tailored to user requirements. Initially, workshops, interviews, etc., must be held to find out what the needs are. Having established the needs, priorities must be set. Objective methods must be developed wherever possible for setting priorities and evaluating alternatives. The user community, Federal, State, university and private, and all the major economic sectors, should participate in all phases of decision making. An intergovernmental advisory group should be established to see that the users of regional to local scale information are adequately served by the integrated data management system.

IMPROVING THE DATA MANAGEMENT SYSTEM

Problems

The National Climate Program Act states that information regarding climate is not fully disseminated or used and that Federal efforts have given insufficient attention to assessing and applying this information. A wide range of problems exist within the data system that limits the application of climate data and information to meet user needs. Examples are incompleteness of records (both manuscript and digital), non-standard records, unrepresented observing sites, inefficient file organization, and difficult access. As a result, the data are frequently of questionable quality in the eyes of the user, or are ignored.

Over the years hundreds of basic atmospheric data sets have been established in response to and in a mode dictated by then existing observation systems and agency needs. These data exist in both digital and hard copy form. The large data files are often cumbersome, expensive to use, and contain numerous duplicates and specialized products. The data vary in quality due to changes over time in observing codes and practices, technology, and data requirements. Many of these changes are undocumented. There is also a serious lack of inventory and guidance material on the use of available data. Gaps and inconsistencies in and between digital sets require specialized editing to make them usable. These and similar problems make it difficult and expensive (in many cases prohibitive) to provide users with data and information that are essential for assessment, applications, and research. Something must be done to improve the data system!

Principles

Data management systems must be responsive to the great diversity of needs imposed by the user community if the objectives of the National Climate Program Act are to be reached. This requires an integrated approach with regional acquisition or data management systems complementing the national system.

The climate data management system should facilitate access to climate data/information in a cost-effective manner, and respect the needs of the user to be able to exploit its products with confidence. A dynamic integrated system is needed. Credibility and use demand appropriate levels of quality control, documentation, inventory, and easy access. An efficient, integrated system will minimize the cost of supplying the data and thereby enhance its use.

Remedial Actions

Editing, quality control, and organization of basic atmospheric data to be compatible with established standards and consistent with user requirements are basic remedial needs. Enlightened data management must consider the spectrum of users, recognize the merits of global data sets and the desirability of regional data management for specialized applications. The existing data base must be upgraded by: (1) editing, (2) determining and recording validity of data, (3) completing digital files by filling in gaps within periods of record, (4) identifying a basic set of selected stations and upgrading their quality for ultra-long periods of record, and (5) completing the inventory of climatic data sets. To further enhance the usefulness and availability of data, station files must be expanded to include history (e.g., changes in instrumentation types, placement, and geographic information) for the sites.

Concurrent with the upgrading of the historical data sets the data acquisition system must be upgraded. Networks must match prime needs. Instruments should be calibrated and compared with national (ANSI) meteorological standards (as developed) at regular time intervals and the results systematically reported to the archiving data center. Measurements should be made comparable by using instruments and practices that meet WMO and ANSI specifications.

The opportunity for efficiency and economy in management and systems offered by new and existing technology must be fully exploited in the interest of fulfilling national and regional needs, within resource limitations. An example is the proposed use of touch-tone telephone pads and INWATS to upgrade the acquisition quality of climatological data. Some data currently being acquired for operational applications are only partially archived, e.g., meteorological satellite data. These should be evaluated to see if they can be further exploited to enhance the utility of the current archive.

AVAILABILITY OF AND ACCESS TO DATA

Problems

As noted the availability of information and systems through which climatological data may be accessed are generally inadequately understood within the user community. On the other hand climate data management has not always been well tuned to user requirements. In many instances, data formats do not meet the user needs, e.g., card formats are still used extensively, whereas the scientific community finds a different format to be incomplete or to include parameters that are not appropriate to the user's problem. There are lags in interfacing technology, and inadequate direction to best sources. Dozens of independently operating, self-contained data systems are functioning on national or regional scales providing access to basic meteorological data for various communities of users. Some of these systems operate relatively unaware of each other's existence and lack the benefits of pooled knowledge and facilities of an integrated system.

Principles

An effective climate data management system must serve the diversity of users. It must be integrated for efficiency and effectiveness. The system must be compatible with other information systems so that the needs for impact or interagency studies, which involve several disciplines, can be readily met. The system should also do more than simply provide a data retrieval service; it should also supply probability statistics, extreme values, comparative information as required for climatic evaluations, and climatic information tailored to decision processes. The nature and capabilities of the system(s) should be well known and for that purpose it is necessary to undertake appropriate promotions or publicity. Furthermore, "linkage" functions and general education on use are essential if the system is to play its proper role in the community.

Remedial Actions

To satisfy climate data needs it is necessary to properly archive, retrieve, and transform the basic atmospheric data. To achieve this goal it is necessary to develop a hierarchal system of integrated data centers and referral systems. There should be linkages between those centers serving global purposes and those serving national, sub-national, and/or regional functions. Pathways to different types of data centers, through an efficient referral and cross-referencing system, must be easily accessible to the user community.

However, mere availability of a data set does not make it a useful climatological data set. Also necessary are the data set "characteristics", e.g., regression equations, analysis scheme changes, or station location changes, to which only the data set generator or climatological community may be privy. Lack of knowledge of these data set "characteristics" could lead to misinterpretation or misuse of the data set and deny the user the additional benefit of information, as opposed to uninterpreted data.

Availability of data sets should be handled by making the user community aware of systems such as ENDEX, OASIS, and DIALOG (see Working Group 7 Report). Questions of user access to the data should be addressed first by studying successful systems already in existence. Some examples are: the Indiana/Purdue Agro-climate computer terminal network which reaches into some 50 counties at present with second order terminal linkages within a county to individual users, the HISAR system for hydrology, and the Georgia based Forest Weather Information Service. State and independent systems must be recognized and supported as component parts of regional to national data management systems. Worth examining are the user services supplied by the California Extension Service and extrapolating such services to meet the widespread need for linkages between users and the data management system.

Finally, if only a poor quality data set is available, its use should not be denied to users until it can be upgraded, especially if it would require several years to do so. Rather, an intermediate version, properly flagged as to limitations, should be made available for use at the user's risk.

RECOMMENDATIONS

1. Take immediate action to assure more complete collection and quality assurance of world-wide conventional surface and upper air data.

These have been and will continue to be the preeminent data for climate services, applications, and assessments.

2. Espouse a data system dedicated to national needs. Insist upon a strong commitment, including resources and promotion by all U.S. climate-oriented agencies.

Inadequate knowledge of data, data sets, data limitations, how to access data sets and their proper use are major obstacles to the success of the National Climate Program. Enhance and widely publicize the system so that all potential users know how to obtain and use climate "information."

3. Develop quantitative bases for rational decisions in the acquisition, collection, archiving, and use of specific data for climate purposes.

At present many major decisions in data management are based on gut-feelings, lobbies, and similar non-objective methods. The development of a quantitative approach is imperative because of the cost of data system operation and the need for optimum service to the Nation.

4. Undertake a program to determine and record station histories and local geography for U.S. data observing sites.

The instrumentation and site characteristics (latitude and longitude, elevation, exposure, land-use characteristics, types of instruments, ...) of world-wide observing locations, and the history of changes in same, are vital information for the climate community. Such a program for U.S. stations must be promoted and fully implemented as a component of any centralized archive facility. Further, the National Climate Program Office (NCPO) should strongly advocate within the World Meteorological Organization (WMO) the development of a world-wide program with similar goals.

5. Define the full spectrum of actual and potential users of climate data/information and their requirements.
6. Continue the strong emphasis on the search for and classification of new data sets for inclusion in the climate data inventory.

This search should continue until it is no longer cost-effective. The current status of the inventory has already revealed many potentially valuable data sets which have had little previous exposure within the user community.

7. Improve the standardization of global climatological data.

World-wide practices in the collection, encoding, and transmission of conventional meteorological and climatological data vary extensively from WMO standards, creating severe decoding and processing problems. These in turn lead to the discard of valuable data, more costly quality control or recovery procedures, and reduced utility of the overall data set. Current and proposed actions of the WMO such as the revision of the synoptic code (1981) and proposed changes in the CLIMAT code have the potential of further enhancing the value of the global data set. Such WMO procedures and intentions deserve the strongest possible support, and the NCPO should be a major advocate thereof.

8. Determine the economic and social value of climatic information.

Studies must be funded or otherwise promoted and enabled through the NCPO. The results of the studies will assist top administrators in setting priorities for the allocation of resources, and assist the NCPO and cooperating agencies in the evaluation of plans and the development of strategies.

9. Establish a Federal/State advisory group to make specific recommendations on climatic data management at the region/State level.

Climatic data sets exist at the Federal level, at the State level, and at sub-State levels, each to serve user groups operating on different though not mutually exclusive space-time-economic scales of activity. The advisory group recommendations are to be referred to agencies concerned for agreed-upon action.

10. Assess the cost effectiveness of unattended data acquisition systems specifically designed for and devoted to obtaining climate data.

Current technology has made remote and/or unattended acquisition of climate data feasible, and perhaps cost effective. This and related technology also offer the potential for meso- or microscale networks to become cost effective because they can free personnel and other resources for application to other high priority requirements. Land-use and similar concerns, particularly in urbanizing areas, create a need for understanding climatology on this small scale. Such systems could be used to offset the degradation in climatological networks that now appears to be resulting from demographic and life-style changes.

11. Evaluate from an archival point of view all new federally funded programs and projects that may generate environmental data.

This should be done during the concept and design phases. If archiving is deemed to be in the national/regional interest, the cost of preparing and archiving the data should be funded as a basic system acquisition cost. Consideration for archiving climate data has traditionally occurred well after the data were being (had been) collected and inadequate funding has led to general deterioration in data services. So that future data collections are more applicable to a wider range of user needs, the NCP should advocate legislation requiring this evaluation.

HYDROLOGY, PRECIPITATION, SNOW AND ICE

Working Group 2

Chairman: Eugene Rasmusson

Members: Roger Barry
David Curtis
Richard Guthrie
Charles Laughlin
James Ormsby
Ward Seguin
Charles R. Showen
John L. Vogel
Donald Wiesnet

INTRODUCTION

In order to deal effectively with the broad range of topics assigned to this working group, the following reviews were prepared by Working Group members prior to the Workshop:

"Streamflow Data" by C. R. Showen, USGS

"Satellite Measurements of Precipitation" by C. Laughlin, NASA

"Contribution of Operational Satellite Data to the Problems of Hydrology - Current and Near Future Recommendations" by D. R. Wiesnet and M. Matson, NOAA/NESS

"Outlook for Remote Sensing of Hydrologic Parameters in the 80's" by J. Ormsby and J. Theon, NASA

"Atmospheric Hydrologic Data" by E. Rasmusson, NOAA/NWS

"Current and Projected Status of the Surface Marine Data Base in Terms of its Use for Estimating Oceanic Evaporation" by W. Seguin, NOAA/EDIS

"Availability of Precipitation Data Over Land - U.S. and Global" by W. Seguin

"Snow and Ice Data" by R. Barry, INSTARR, U. of Colorado

"Small Scale Variability of Land Surface Hydrologic Parameters", by J. Vogel, Illinois Water Survey

"Land Use and Land Cover Data Requirements for Modeling of Surface Hydrologic Processes" by D. Curtis, NOAA/NWS

Most of these reviews were circulated to working group members prior to the Workshop. During the Workshop, the papers were discussed, revised, and in some cases rearranged or consolidated around more appropriate topics. The final result was seven summary reports on the following topics:

- Streamflow and Groundwater Data
- Conventional Precipitation Data Over Land
- Satellite Measurement of Precipitation
- Snow and Ice Data
- Requirements for Modeling of Surface Hydrologic Processes
- Ocean Evaporation
- Atmospheric Hydrologic Data

These summary papers are included as part of this report.

After reviewing and discussing the content of these papers, and coordinating overlapping areas of interest with other working groups, the members of Working Group 2 wish to make the following recommendations:

RECOMMENDATIONS

STREAMFLOW AND GROUNDWATER DATA

1. Expand the National Water Data Exchange (NAWDEX) of the USGS to an international inventory and exchange system for streamflow and groundwater information.

The structure for expanding NAWDEX to an international system is in place, and some Canadian and Mexican information is already incorporated into the system. U.S. members of NAWDEX are required to sign a memorandum of understanding. In the case of foreign data, an informal exchange program is established and the foreign organizations are identified as affiliates. It is not effective to develop an international system of data exchange through a series of individual bilateral arrangements. Rather, as in the case of meteorological data, an overall structure for data exchange should be developed through an appropriate international organization such as the World Meteorological Organization (WMO) or the United Nations Educational, Scientific and Cultural Organization (UNESCO). It is recommended that the National Climate Program Office (NCPO), working closely with NOAA and USGS, assume the lead role in the development of this structure in the United States.

2. Expand the Water Data Storage and Retrieval System (WATSTORE) of the USGS into an archive for international streamflow and groundwater data.

Although WATSTORE should serve as the central archive for basic streamflow and groundwater data, it will undoubtedly be desirable to prepare subsets and special summary products from these data for specific climate applications. These derived products should be developed as the need arises.

3. Develop a consolidated station history file for stream gaging stations.

Information on stream gaging stations is at present scattered throughout a variety of publications and organizations. Auxiliary information such as gaging station history and changes in channel characteristics, diversions, and storage are required for proper interpretation of streamflow data within the context of the climate program. A comprehensive assembly of these data, for both United States and foreign gaging stations, should proceed along with the indexing and exchange of these data.

CONVENTIONAL PRECIPITATION DATA OVER LAND

The following recommendations are made to improve the accessibility and utility of the conventional precipitation data sets. They are made within the framework of data: (1) acquisition; (2) editing, validation and enhancement; (3) archiving; (4) distribution; and (5) evaluation. The recommendations for the acquisition of data are further subdivided into the international, national, and regional scale. The recommendations apply to all levels of precipitation data.

1. Take vigorous action to bring about increased compliance with synoptic coding and transmission standards for precipitation data.

Precipitation data is required on a global basis for applications such as crop assessment. Although subsynoptic scale coverage is needed, the reports from the World Weather Watch (WWW) Synoptic Network now constitute the basic source of real time global precipitation data. Failure to transmit these data in accordance with established international standards results in data far short of its potential. The NCPO should take vigorous action through the WMO to bring about increased compliance with synoptic coding and transmitting standards, and assure that the effective transmission of precipitation data be a prime consideration when changes in the synoptic code are considered.

2. Conduct a systematic evaluation of the requirements for the U.S. substation precipitation network.

It is recommended that (1) the NMC and cooperative substation networks be maintained in their present state until a clear demonstration can be made of the precipitation requirements of the National Climate Program (NCP), and (2) a systematic evaluation of the precipitation network requirements be made using economic and climate-dependent models. This evaluation process would be similar to network studies performed in the late 1960s to determine the optimum distribution of upper-air reporting stations required for numerical modeling efforts.

3. Establish an inventory of data from special precipitation networks.

On the local or regional scale the NCP should establish a dynamic inventory system of all special precipitation networks, whether they be short-term or continuous. Careful preparation must be made to ensure that such an inventory gives a complete description of each network, the data type, and its availability.

Archiving of special network data should be encouraged, although not necessarily at a single data center. Particular emphasis should be placed on data derived from very high density gage networks, or high resolution mappings of the precipitation field derived through the combination of quantitative radar data and data from conventional precipitation gages. In addition, the NCP should encourage the establishment of local and regional precipitation networks to establish the natural variability of precipitation and its relation to hydro-climatic parameters such as soil moisture, runoff, and soil erosion.

4. Include proper documentation of network characteristics and processing procedures with precipitation data sets.

Proper documentation for the observational network and data processing procedures is essential for the effective use of precipitation data. It should be an accepted principle of data management that such supporting information constitutes an integral part of the data base as the data values themselves. Such information includes documentation of site locations, instrument types, length of record, data processing operations, and known deficiencies in the data.

The possibility of estimating rainfall from satellite data on a global basis exists through the use of passive microwave radiometry, active radar, and visible and infrared imagery. No other reasonable possibility now exists for obtaining comprehensive coverage over the world oceans. Even over land, the conventional point precipitation networks are generally inadequate to resolve small-scale variations and provide reliable areally averaged values. Microwave, as employed by the Nimbus-5 Electronically Scanned Microwave Radiometer (ESMR), may be suitable for global ocean studies but unsuitable for local land-based hydrologic applications. Visible and IR cloud-top temperature techniques used together with other ancillary data and information may be most applicable to convective rainfall situations, and most effective for local and regional studies.

1. Develop sites for evaluating satellite precipitation estimation techniques.

It is essential that the accuracy and sphere of usefulness of existing techniques for satellite estimation of precipitation be evaluated and objectively documented, since these methods are still in the development state. Test sites for carrying out this verification over land areas should be designated for several climatic zones (tropical, temperate, arctic, etc.). The temporal/spatial frequency of surface precipitation observations should be comparable to at least that of the GARP Atlantic Tropical Experiment (GATE) B array. In deference to fiscal constraints, these test sites should be selected from currently well-instrumented test areas wherever possible. Examples over the United States are (1) the South Dakota State University weather radar and rain gage network; (2) the precipitation gage network at Chickashaw, Oklahoma; and (3) the flash flood network being developed by NWS in the Appalachian area.

As an initial step in testing passive microwave radiometry methods over ocean areas, further studies should be made using the GATE ESMR and radar data to determine both the capabilities and limitations of ESMR in providing rainfall rates over oceans, and from this determine the desirability of processing the remaining ESMR data. Such studies would also suggest future directions for research in passive radiometry, and provide a basis for judging the potential of the improved measurement accuracy offered by radar techniques.

2. Develop a precipitation data base for use in satellite systems design.

A need exists for basic data on the statistical properties, both in time and space, of precipitating systems for use in satellite/sensor systems design. As a result, a reasonable basis for determination of system specifications such as the microwave antenna size required (and corresponding beam-width and ground resolution) is lacking. It is, therefore, further recommended that the most interested agencies, NOAA and NASA, take the lead in developing the requirements for such a data set, and take steps to acquire and assemble the required data.

SNOW AND ICE DATA

1. Digital data bases of variables characterizing global snow cover and sea ice must be developed in grid format. Initially, (1) Operational snow and ice chart products should be evaluated for possible digitization. (2) The new series of 7-day Composite Minimum Brightness (CMB) Charts from NOAA/NESS should be recorded in digital form at NESS prior to archiving at EDIS.
2. High priority should be given to continuing the development of inventories for the major variables characterizing global snow cover and sea ice.
3. Recognizing the valuable property of microwave sensors to penetrate clouds, the usefulness of ESMR microwave observations of polar area snow and sea ice should be evaluated.
4. Support must be given to providing the auxiliary data needed for studies involving interaction with snow cover.

These data include geographic data on terrain characteristics, vegetation cover, land use, as well as temperature, radiation, and wind speed data.

5. To facilitate international exchange of ice and snow data, national agencies are encouraged to send data, information, and user requests to the WDC-A for glaciology (Snow and Ice).

REQUIREMENTS FOR MODELING OF SURFACE HYDROLOGIC PROCESSES

(Also see recommendations of Working Group 6)

1. Develop coordinated soil data base management systems.

Several Federal and State agencies are independently undertaking the tasks of digitizing soil survey maps and

construction of computer oriented soil data base systems. The purpose, scope, and execution of each agency's effort is varied, as are the levels of financial support. Therefore, to optimize the utility of soils data to the National Climate Program, the Working Group recommends a coordinated national emphasis on the development of soil data base management systems. No new data collection programs are proposed by this recommendation. Rather, existing information found in tabular and map form should be digitized and formatted for interactive availability. Additionally, the soil from which data have been acquired should be properly classified before the data are archived. Soils data from local, regional, and international sources should be included.

2. Develop a central archive of time series of soil moisture measurements.

About 200 soil-vegetation records have been uncovered in a recent survey of available soil moisture data. They include several studies mainly at Science Education Administration-Agricultural Research (SEA-AR) research stations scattered throughout the United States. A 5-year soil moisture pilot study is proposed by the Soil Conservation Service (SCS) in cooperation with SEA-AR and State Agricultural Experiment Stations. It is recommended, that time series of directly measured soil moisture, which are becoming available in increasing numbers, be centrally archived, and that consideration be given to making these data available for general use, perhaps through interactive computer systems. It is recommended that USDA assume the lead in this effort.

3. Encourage research programs for the development of technologies to remotely sense soil moisture.

Recognizing the difficulty of obtaining useful coarse grid estimates of soil moisture, it is recommended that the NCPO serve as the focal point for coordinating and encouraging research programs for the continued development of technologies to remotely sense "grid-scale" soil moisture on a regional and global scale.

OCEAN EVAPORATION

See recommendation of Working Group 3 concerning the development of the surface marine data base.

ATMOSPHERIC HYDROLOGIC DATA

The operational rawinsonde network continues to provide the basic moisture and wind data for evaluating the atmospheric hydrologic cycle. Because of special data problems and requirements, much of the archived rawinsonde data is inadequate or only marginally adequate for these computations.

Recommendation

The N.C.C. should make the archived rawinsonde data more useful for atmospheric water balance computations. (1) the corresponding surface observation be archived with the upper level data; (2) data be regularly computed, transmitted and archived at 50-mb intervals, at least for the layer below 850 mb; and (3) documentation of instrument type, including humidity element, known biases, and established methods for correcting the data be included as an integral part of the rawinsonde data archive.

SUMMARY PAPERS

STREAMFLOW AND GROUNDWATER DATA

Source of Data

The U.S. Geological Survey (USGS) collects streamflow information at about 9,000 sites, which represent about 80 percent of the streamflow data that is collected in the United States. The Office of Water Data Coordination (OWDC) of the USGS impaneled a Federal Interagency Work Group for Designation of Standards for Water Data Acquisition. The report of the work group on surface water, including storage, stage, streamflow, and gage data, will be published in late 1979. The establishment of standardized methods for acquiring surface water data will enable comparison of data collected by different individuals or agencies. Without standards, the validity of much irreplaceable data that was costly and time consuming to acquire would be questionable. Streamflow data at international gaging stations on the borders of Canada and Mexico are available from the Water Survey of Canada and the International Boundary and Water Commission. The availability of streamflow data on a global basis varies country-by-country. For example, the Hashemite Kingdom of Jordan collects streamflow information, but due to lack of experienced personnel the data are not computed and published on a regular basis. In other countries, such as Australia and New Zealand, the data are no longer published but finalized data are available from the agency that collected the data.

Data Formats

Since about 1968, most of the streamflow data collected in the United States have been collected in digital form. The data are automatically punched on tape at 15-, 30-, or 60-minute intervals. This detailed hydrograph information is available in machine-readable form through the local USGS office, which is generally located in the State Capitol. On a global basis, most streamflow data are available in manuscript form, such as strip charts or daily readings by local observers. Data accuracy will vary considerably depending on the physical conditions at the site and the techniques employed by the country that collects the data.

Future Plans

The USGS is evaluating satellite technology that is expected to provide a cost-effective technique for the automatic collection of data from hydrologic stations. These data include water stage, water quality, precipitation, and snow depth. This technology, which is referred to as satellite Data Collection Systems (DCS), provides an opportunity to collect data from inexpensive battery-operated radios located at literally tens of thousands of hydrologic stations distributed over national or continental areas. The availability of real time-processed hydrologic data will aid in flood forecasting and provide for more effective water-resources management.

Data Management

The user of U.S. streamflow data faces a bewildering problem in trying to determine if the specific information he needs has been collected, and where it is available. Because of the lack of a requirement for large-scale international data exchange, arrangements such as those developed through necessity for meteorological data do not now exist for streamflow and ground-water data.

To help solve these problems on the national level, the National Water Data Exchange (NAWDEX) was established within the USGS. NAWDEX is a national confederation of water-oriented organizations working together to improve access to water data. Its primary objective is to assist users of water data in the identification, location, and acquisition of needed data. It consists of two data bases. The first is a Master Water Data Index which identifies specific sites for which water data are available, and provides information on types of data, periods for which data are available, parameters, frequency of observations, and media. The second data base consists of the Water Data Sources Directory, which identifies organizations that are sources of water data. The NAWDEX Program Office

encompasses four major areas of operation: (1) maintaining an internal data center, including access to automated data processing facilities for maintenance and use of its information files, (2) indexing water data held by participating organizations, (3) providing facilities and personnel for responding to requests for water data, and (4) formulating recommended water data handling and exchange standards.

The function of NAWDEX is not to become a repository of water data. Instead, the Program Office indexes the data held by NAWDEX members and participants to provide a central source of water-data information available from a large number of organizations. These data may be in computerized and non-computerized form.

The National Water Data Storage and Retrieval System (WATSTORE) was established in November 1971 to modernize the USGS existing water-data processing procedures and techniques, and to provide for more effective and efficient management of its data releasing activities.

The WATSTORE System consists of several files in which data are grouped and stored by common characteristics and data collection frequencies. Currently, files are maintained for the storage of (1) surfacewater, quality-of-water, and groundwater data measured on a daily or continuous basis; (2) annual peak values for streamflow stations; (3) chemical analyses for surface- and groundwater sites; and (4) geologic and inventory data for groundwater sites. The daily values file includes data for streamflow values, river states, reservoir contents, water temperatures, sediment discharges, and groundwater levels.

Recommendations

1. Expand NAWDEX to an international inventory and exchange system for streamflow and groundwater information.

The structure for expanding NAWDEX to an international system is in place, and some Canadian and Mexican information is now incorporated in the system. U.S. members of NAWDEX are required to sign a memorandum of understanding. In the case of foreign data, an informal exchange program is established and the foreign organizations are identified as affiliates.

It is not effective to develop an international system of data exchange through a series of individual bilateral arrangements. Rather, as in the case of meteorological data, an overall structure for data exchange should be developed through an appropriate international organization

such as the WMO or UNESCO. It is recommended that the NCPO assume the U.S. lead role in the development of this structure.

2. Expand WATSTORE into an archive for international stream-flow and groundwater data.

Although WATSTORE should serve as the central archive for basic streamflow and groundwater data, it will undoubtedly be desirable to prepare subsets and special summary products from these data for specific climate applications. These derived products should be developed as the need arises.

3. Develop a consolidated station history file for stream gaging stations.

Information on stream gaging stations is at present scattered throughout a variety of publications and organizations. Auxiliary information such as gaging station history, and changes in channel characteristics, diversions, and storage are required for proper interpretation of stream-flow data within the context of the climate program. The USCPO should assure that comprehensive assembly of this information for both U.S. and foreign gaging stations proceed along with the indexing and exchange of these data.

CONVENTIONAL PRECIPITATION DATA OVER LAND

U.S. and Global

Introduction

Conventional precipitation data are very important to the climate initiatives of the 1980s and beyond. Precipitation data are used for agriculture, energy and water resource purposes, for predicting the overall health of the world's economies, and to specify the hydrologic cycle which is fundamental to climate forecast models. The data are used to evaluate soil moisture, evaporation rates, and erosion for land resource studies, and provide a baseline with which we can study and evaluate potential climate change whether natural or man-made.

Precipitation data are used by many diverse groups including government units, architects, attorneys, engineers, and people in health, insurance, manufacturing, recreation, transportation, and utilities. These groups derive their data from international, national, and regional sources, whose requirements vary with the users.

Global precipitation data are required to aid in the forecast of global crop production and to determine the ability of nations to produce energy using hydroelectric energy production. Precipitation data are needed on a national scale by government and private groups for use in long-range planning, policy, design, management, education, and documentation of factual records. On a regional scale the data are used for a multitude of specialized requirements ranging from the determination of precipitation effects on soil moisture and other hydrologic effects and the possible influence by man upon urban environments or local climate through planned weather modification.

Therefore, the National Climate Plan should include a comprehensive plan to ensure the systematic collection, processing, and dissemination of precipitation data and information. This includes providing quality controlled data in both raw and processed form. Additional emphasis should be placed on the quality, density, and continuity of reporting stations, the accessibility of data and information, and the timeliness of the data.

Present Data Status

The National Climatic Center (NCC) receives precipitation data for thousands of stations in the United States and the world. These data are received on different media including logs or forms, strip charts, punched paper tape, publications, and magnetic tape. The time resolution varies from continuous (e.g., strip charts) to monthly summaries (e.g., CLIMAT reports).

Some data are edited carefully, while others are little more than scanned, and some simply are inventoried and archived. NCC archives the manuscript data, computes and prepares digital tape files, and publishes a number of monthly and annual summaries. Some tape files serve specific users such as NOAA's Office of Hydrology. The publications, history, and the information contained in various precipitation data bases are summarized in an EDIS report: Selective Guide to Climatic Data Sources. Canada publishes a similar report entitled Handbook on Climatological Data Sources of the Atmospheric Environment Service.

International data are relatively scarce. A monthly summary of precipitation data for hundreds of stations throughout the world, which are derived from CLIMAT reports, are published each month in Monthly Climatic Data for the World. The publication originated in May 1948 under the title Monthly Climatic Data for the World by Continents. It is jointly sponsored by the World Meteorological Organization (WMO) and NOAA.

The corresponding digital tape file is the Monthly Global Land Surface data for about 1,500 global stations. Parts of the data extend as far back as the 1700s and contain total precipitation, among other variables, for each month.

Recently the NCC began to receive decoded daily and shorter term global precipitation data from the Center for Environmental Assessment Services (CEAS) of EDIS, who decode global telecommunications as part of its crop assessment service. However, these data are incomplete because of data loss in transmission and poor international coding practices. Documentation of data problems, instrumentation and observing practices is either nonexistent or at best lacking.

Precipitation data have been processed and documented for a number of short duration experiments such as the Barbados Oceanographic and Atmospheric Experiment (BOMEX) and the GARP Atlantic Tropical Experiment (GATE). These are available from NCC.

Precipitation data for national networks are available in several forms from the NCC including raw manuscript forms, publications, and computer tape files. The four monthly publications summarizing the U.S. precipitation data by State are listed here:

1. Local Climatological Data (monthly), and the Local Climatological Data, Annual Summary with Comparative Data. The monthly issue presents basic climatological data together with a table of hourly precipitation by month for each of the first order weather stations (approximately 300). Predecessor issues were first published as the Monthly Meteorological Summary in 1897. The first Annual Meteorological Summary was published in 1909; today it contains sequential and annual tables for rain and snowfall, among other variables.
2. Climatological Data (monthly and annual) is published for each State or combination of States (Maryland-Delaware, New England; the Pacific area; and Puerto Rico and the Virgin Islands). It was first published by the Weather Bureau as the Climatological Service Bulletin beginning in February 1906. Monthly issues contain a daily precipitation table for some 9,000 stations, and annual issues contain monthly and annual total precipitation and departures from normals.
3. Hourly Precipitation Data is published for each State or combination of States (Maryland-Delaware, New England) except Alaska. The predecessor publication known as the Hydrologic Bulletin was issued by drainage districts,

and began publication in January 1940. The monthly issue presents daily and hourly precipitation data from about 3,000 stations equipped with automatic recording gages. The annual issue contains monthly and annual totals of precipitation.

4. Climatological Data, National Summary is issued monthly and annually, and contains selected climatological data on a national basis. It began with the 1950 issue, but prior to that much of the data appeared in the Monthly Weather Review, the U.S. Meteorological Yearbook, and the Report of the Chief of the Weather Bureau. It contains, among other variables, the greatest and least monthly totals of precipitation for each State, together with the names of the locations at which they occurred; and maps depicting total precipitation and percentage of normal precipitation. The annual issue gives maps of total annual precipitation and percentage of normal annual precipitation.

The principal computer precipitation tape files in the NCC library are listed below:

1. Summary of the day data files for the cooperative observer network contain daily precipitation and extend back to the late 1800s for selected stations. Currently, precipitation data for approximately 9,000 stations are being added to the files.
2. Summary of the day data files for the first order National Weather Service stations contain daily precipitation beginning in 1948.
3. Hourly precipitation data files for the 3,000 universal and Fischer-Porter gages begins in 1948.
4. Monthly United States Land Surface data contain monthly totals of precipitation data for approximately 10,000 current cooperative stations with data for some stations extending back to 1900.

The National Weather Service has a number of different observing networks which fall into one of two general classes: the first order stations, which include the principal NWS forecast and observing stations as well as certain FAA stations, and the substation networks. The substation networks are made up of the A-network, the basic climatic network; the B-network, the basic hydrologic network; and the C-network, a local service network. A few stations have been placed in an X-network category which consists of long-term stations transferred from the C-network. These are to be kept open through 1980, at which time their usefulness will be reexamined.

Station histories are generally available for all of the national stations, although many need to be updated. Likewise, documentation on instrumentation used is available, but documentation on data quality or problems of individual stations generally is not available.

Regional and local precipitation network data are available from a variety of sources ranging from private organizations and local governments to State and Federal agencies. Some networks are designed to supplement the cooperative substation network on a State or regional basis and are operated on a continuing basis. Examples are networks operated by the State of California and the TVA. Other networks are operated to describe local or subregional precipitation processes such as urban precipitation networks (Chicago and San Francisco) to monitor and identify urban hydrology problems. Other networks are designed to determine various relations between precipitation and hydrologic parameters such as runoff, soil moisture, and soil erosion.

The Atmospheric Environment Service (AES) of Canada is developing a national network of C-band quantitative weather radars with a digital recording and transmission capability. Digital data from this network are used to create a national archive of good quality, easily accessible, quantitative radar data. Single time, software development permits the initiation of a radar climatology program for the entire network and special analysis programs for one area of the country are readily usable at the other sites in the network.

Additional special networks are operated on a short-term basis for specific purposes. Some have detailed rainfall information, such as METROMEX, which documented the rainfall distribution around a large urban-industrial complex for a 5-year period to evaluate inadvertent precipitation effects and the Thunderstorm Project networks of the mid 1940s, which were designed to help understand thunderstorm dynamics. Other networks, operated by local or regional groups, measure rainfall amounts to determine the optimum harvesting period of crops, to evaluate weather modification experiments, and for other special purposes. The quality and accessibility of those records range from wholly inadequate to ready retrieval of the data.

Recommendations

The following recommendations are made to improve the accessibility and utility of the conventional precipitation data sets. They are made within the framework of data: (1) acquisition; (2) editing, validation, and enhancement; (3) archiving; (4) distribution; and (5) evaluation. The recommendations for the acquisition of data are further subdivided into the international, national, and regional

scale. The remaining recommendations apply to all levels of precipitation data.

The necessary flow of precipitation data to evaluate global needs requires that (1) the international community be approached to ensure the continued flow of summarized and raw data; (2) efforts should be made to upgrade the quality and quantity of international precipitation data; and (3) standards be established and followed for the international transmission of global precipitation data. The last recommendation is especially important in light of the proposed changes in the synoptic code scheduled to occur in the early 1980s.

Nationally, it is recommended that (1) the NMC and cooperative substation networks be continued in their present state until a clear demonstration can be made of the precipitation requirements of the National Climate Program; and (2) a systematic evaluation of the precipitation network requirements be made using economic and climate dependent models. This evaluation process would be similar to studies performed during the 1960s to determine the optimum distribution of upper-air reporting stations for numerical modeling efforts.

On the local or regional scale the National Climate Program should establish a dynamic inventory system of all special precipitation and quantitative weather radar networks, whether they be short-term or continuous. Careful preparation must be made to ensure that such an inventory gives a complete description of each network, the data, and its availability.

In addition, the National Climate Program should encourage the establishment of local and regional precipitation networks to measure the natural variability of precipitation and its relation to hydro-climatic parameters such as soil moisture, runoff, and soil erosion. Additional local or regional networks should be established and operated for a sufficient length of time to define hydro-climatic effects of new technologies with the potential of inadvertently modifying the local or regional hydrologic cycle.

For proper editing, validation, and enhancement of precipitation data, it is encouraged that there be (1) careful documentation of all data processing and irregularities; (2) documentation of instrument types, accuracy, and site locations; (3) documentation of the data processing and history of each site automatically made available to users; (4) re-processing of historical data sets to eliminate or correct errors; and (5) an effort to maintain all data sets with the highest possible temporal and spatial resolution.

For the proper archiving of precipitation data it is recommended that (1) all data be duplicated with the originals and duplicates stored separately; and (2) all data sets should be made complete and extended back into time if feasible.

The efficient distribution of precipitation data requires that (1) on-line data inventories be provided and that they should be continually updated; and (2) data should be made available as fast as is practical.

An evaluation mechanism should be established so the data user can indicate data problems and inadequacies, and this mechanism must provide procedure to ensure that remedial actions will be taken promptly.

SATELLITE MEASUREMENTS OF PRECIPITATION

Visible and Infrared Imagery

Several methods for estimating rainfall using satellite imagery have been developed. These methods depend on empirical relationships between the cloud brightness and rainfall amount which, at best, apply to limited convective rainfall situations. These methods generally define the area of cloudiness very well. However, due to the rapid growth of convective clouds, rainfall estimates based on images every 30 minutes or longer are questionable.

Visible and infrared radiation from polar orbiting and geostationary satellites have been used to give areal and time averages of precipitation mainly by monitoring the growth rate of the convective clouds, and cloud top brightness temperature and significant cloud features. Geostationary Operational Environmental Satellite (GOES) visible images have been used to estimate areal 24-hour total rainfall. On a finer scale, 30-minute rainfall has been estimated using NOAA visible and IR data. The error of the estimates was on the order of a factor of two for both of these studies. Future polar orbiters that carry visible and IR scanners along with microwave sensors could calibrate rainfall estimates from GOES 30-minute VISSR data and thereby provide better temporal rainfall coverage.

A simple but effective technique was developed which uses daily satellite visible images of clouds to infer rainfall over land areas during daylight hours. Cloud type, extent, and persistence over a given region are determined from the (low orbiting) satellite images. These factors are used empirically, together with a surface gage network (sparse though it may be), to "calibrate" the precipitation associated

with the observed clouds. Integration of the semidiurnal values and patterns then provides total rainfall. The region to be calibrated is carefully selected to account for orographic and maritime influences. This technique has been used in underdeveloped countries where the number of surface rain gage stations are very limited. The technique is claimed to be capable of providing detailed patterns and accuracies to within 75 percent.

Active Microwave (Radar)

Microwave radar offers the most promise for observations of rain over land. Using narrow pencil beams and range gating, effects of ground reflectivity can be estimated. Concept studies have found that a high resolution multibeam radar can accurately profile precipitation over land and ocean for rain rates in excess of 40 mm/hr.

Multibeam radars may be either of the fixed beam (pushbroom) or scanning beam type. The fixed-beam phased array antenna is a more complex electromagnetic design. However, being stationary, it poses less problem to the spacecraft than a mechanically-scanned antenna. The mechanically-scanned multibeam radar is the simplest antenna system design, and single and dual reflector configurations are feasible, but mechanically-scanned antennas generally present considerable momentum-compensation problems.

Radars offer unique advantages over radiometers: (a) the precipitation profile in range may be determined rather than just a height-averaged value; (b) the range of rain rates observable extends from 1 to as much as 200 mm/hr; and (c) system designs have been analyzed that offer reasonably high confidence in rain-over-land applications. These advantages are, of course, acquired at the expense of system complexity, cost, size, and weight.

Passive Microwave Radiometry

The microwave brightness temperature as observed from a satellite depends on the emission from the Earth's surface as well as that of the intervening atmosphere. The emissivity of the ocean surface is more or less uniform at the 1.55 cm wavelength and has a low value of 0.4. This low emissivity provides the needed contrast to distinguish between the emission from the ocean surface and the emission from atmospheric constituents. In an atmosphere with rain, three major constituents contribute to the emission, i.e., molecular oxygen, water vapor, and liquid water droplets. When water droplets are present, they are the main source of scattering of microwave radiation in the atmosphere. The microwave brightness temperature

for different rainfall rates can be calculated by numerically solving the radiative transfer equation.

Comparisons of simultaneous measurements of rain rate by radar and microwave brightness temperature over the ocean area have been made to confirm the theoretical model.

Microwave radiometric observation of rain over the ocean is made possible by the low background brightness temperature of the highly reflective (low emissivity) ocean. Studies have shown that rain areas can often be mapped over land when the ground is wet and temperatures are above 15°C. Algorithms and models presently under development for retrieval of rain from microwave radiometers suggest that improved observation of rain can be achieved with microwave radiometers at both 37 GHz (SMMR and Nimbus-6 ESMR) and 94 GHz.

Sampling Errors

The present estimate of the passive microwave accuracy is based partly on subjective considerations and partly on observations. Between 1 and 20 mm/hr, a 1-km error in the assumed freezing level can result in an error in rainfall rate of about 20 percent. Beyond this measurement error, a time series limited to a finite number of observations, such as that produced by the ESMR, can result in a sampling error that might even overwhelm the instrumental error for single observations.

However, the standard error for satellite-derived monthly mean estimates is reduced by virtue of the number of independent samples obtained over a month's duration. Current estimates are that the monthly mean fluctuation errors over ocean areas are on the order of 8 percent. Another major source of error results from the nonlinear nature of the brightness versus rainfall relationship. Present limitations on antenna dimensions result in a footprint area that exceeds the typical size of rain cells. As a result, the precipitation often does not fill the beam pattern and a bias is produced. Current estimates are that the monthly mean rainfall may be underestimated by an amount of about 60 percent of the true mean.

Status of Satellite Precipitation Data

Weekly, monthly, seasonally, and annually averaged rainfall maps for ocean areas derived from the Nimbus-5 Electrically Scanned Microwave Radiometer (ESMR) instrument have been published in the form of an atlas. These are in general agreement with available conventional rainfall data. They depict known characteristics of global patterns and they suggest new and interesting climatological features, including a potential for predicting the onset and development of the South-east Asia monsoon.

Because of limitations in measurement accuracy, and others due to methods used in generating the rain atlas, the authors make no claim for accuracy to better than a factor of two, although in a relative sense, they believe the results are much more dependable when changes are considered. In spite of the fact that estimates of the validity of the ESMR-derived rain maps cannot yet be quantitatively stated, and it cannot be said with certainty that their accuracy is either limited by instrumental errors, sampling errors, or indeed a combination of the two, they do appear to be significant and valuable.

Several interesting aspects of global climatology are evident from these maps. The monthly maps reveal the displacement of rain belts and changes in intensity of the ITCZ rain pattern (the forking in the Pacific with the southern limb merging as it runs southeast with the polar front) throws further light on the observations of a dry zone near the Ellice Islands in the mid-Pacific. The rainfall rate over the oceans appears to be less in the Southern Hemisphere than in the Northern Hemisphere, particularly in the Atlantic. There appears to be a regular evolution of the maxima with the progression of the seasons.

In the Pacific, the ITCZ shows a general displacement to the north of the Equator and is more sharply defined, and its seasonal movement more pronounced, in the Atlantic. The polar front near 40°N appears more active from September through November, whereas its weaker complement in the Southern Hemisphere is most active from March through May. Two main maxima appear in the Indian Ocean, the one at higher latitude growing at the expense of the other at lower latitudes as the monsoon advances, and vice versa as it retreats.

The weekly maps portray the onset and retreat of the Southwest monsoon. According to the official Indian weather summary, in 1973 the date of onset of the monsoon to peninsular India was June 10, and the date of withdrawal from the main part of that region was October 16. This closely corresponds to the ESMR data and indicates the feasibility of satellite monitoring to predict its onset and later development.

Precipitation estimates are currently made entirely on a research basis at NOAA, but are evolving into an integral part of a newly developing flash-flood warning system. NESS in cooperation with NWS is using the Oliver-Scofield technique based on GOES/VISSR data at half-hourly intervals. The Griffith-Woodley technique is used in Florida. None of the existing techniques have been adequately evaluated, although comparisons with individual storms have been made. GOES IR data on which these techniques are based are currently archived by NOAA/EDIS.

Data Management Strategy

While all current techniques for the estimation of precipitation from satellites are still in the realm of research, enough promise has been demonstrated to permit consideration of a strategy for management of the data. At the same time, it is senseless to expend large amounts of money on processing and storing data whose reliability is questionable and whose utility is yet unknown. A reasonable estimate for careful analysis of the ESMR-5 data is in the neighborhood of one million dollars. While this is a small amount compared to the cost for its original collection, it is still considerable and would take resources that could otherwise be devoted to other data.

As a result, a detailed plan needs to be developed based on an overall strategy leading from initial assessment and validation to final processing and archiving only when the value has been established at each step. Case studies and physical process studies may be individually justifiable and in general do not require treatment of the entire data set. On the other hand, climatic data sets involving temporal and spatial averages must take into account the finite sampling limitations of the satellite data. In addition to the temporal sampling, satellite measurements are spatial averages over the area in view and validations through ground measurements are difficult.

As the resolution capabilities of polar-orbiting remote sensors are improved to provide the kind of information needed to describe the processes accurately on a local, regional, or global level, the volume of data will grow considerably. With global coverage repeated one or two times per day (visible vs IR and microwave), the quantities of data available can soon become overwhelming. (See chart on following page.)

All too often in the past, the data processing and management systems of satellite missions have been neglected. Initially, this neglect probably resulted from the failure to recognize the magnitude of the problem. Once the data were collected no provisions were made to fully process, archive, and distribute them to users. Too often, overruns in the costs of hardware systems drained the funds budgeted for data processing. Thus, we find ourselves with thousands of magnetic tapes containing satellite observations which are not fully processed and cannot be retrieved readily. It is true that some of these data are not suitable either because of limitations in the instrument, the orbit, or the spacecraft. In other cases, a large and expensive effort must be mounted to process data which meet the accuracy and coverage requirements. In any case, recognition and acceptance of the true costs of data processing and management must be a part of the planning of such

missions. It will only be possible to reap the true potential of remote sensing capabilities when the large body of data is made available for applications to the problems of climate.

DATA RATES

Satellite	Sensors	Channels	Data Rate (b/s)	Swath Width	Resolution
<u>Current</u>					
Nimbus-7	SMMR	5	2K	800 km	30-150 km
Seasat-A	SAR	1	15-24 M	100 km	25 km
TIROS-N	AVHRR	4,5	600 K	horiz to horiz	1 km
GOES	VISSR	2	28 M	full disc	1 km, VIS 8 km IR
<u>Under Study</u>					
Imaging radar 1980s	21 cm L-band		50 M	100-200 km	25-100 M
Multichannel Passive Microwave	K to P band		low	100 km	20-50 km

Recommendations

The possibility of estimating rainfall from satellite data on a global basis exists through the use of visible and infrared imagery, and active and passive microwave radiometry. No other reasonable possibility now exists for obtaining comprehensive coverage over the world oceans. Even over land, the conventional point precipitation networks are generally inadequate to resolve small scale variations to the level required for reliable areally averaged values.

Microwave (e.g., ESMR) techniques for precipitation estimation may be suitable for global studies but unsuitable for certain local hydrologic forecasts. IR or cloud-top temperature techniques, such as the Oliver-Schofield or Griffith-Woodley methods are most applicable to convective rainfall situations, and may be most effective for local and regional studies.

1. Develop sites for testing satellite techniques for estimating precipitation.

Since these methods are still in the development state, it is essential that the accuracy and sphere of usefulness of existing techniques for satellite estimation of precipitation be evaluated and objectively documented.

Test sites for carrying out this verification over land areas should be designated for several climatic zones (tropical, temperate, arctic, etc.). The time/space frequency of surface precipitation observations should be comparable to that of the GATE A/B array. In deference to fiscal constraints, these test sites should be selected from currently well-instrumented test areas wherever possible. Examples over the United States are (1) the South Dakota State University weather radar and rain gage network; (2) the precipitation gage network at Chickashaw, Oklahoma; and (3) the flash flood network being developed by NWS in the Appalachian area.

As an initial step in testing these methods over ocean areas, further studies should be made using the GATE ESMR and radar data to first determine the capability of ESMR to provide rainfall rates over oceans, and from this determine the desirability of processing the remaining ESMR data.

2. Develop a precipitation data base for use in satellite systems design.

A need exists for basic data on the statistical structure, in both time and space, of precipitating systems for use in satellite/sensor systems design. As a result of this shortage of climatological data, a reasonable basis for the selection of a microwave antenna size (and corresponding beamwidth and ground resolution) is lacking. It is therefore recommended that the most interested agencies, NOAA and NASA, take the lead in developing the requirements for such a data set, and take steps to assemble or acquire the required data.

SNOW AND ICE DATA

Introduction

Snow and ice cover in polar regions is recognized to be a sensitive index of global climate. Study of the processes involved in atmosphere/surface exchanges involving the

cryosphere are identified as a significant problem area for Climate Program research. Major seasonal changes in the extent, thickness, and surface characteristics of snow cover and sea ice influence the energy fluxes at the interface which, in turn, contribute to the forcing of both atmospheric circulation and local mesoscale systems. Long-term changes in sea and land ice cover, including the glacial maxima and so-called Little Ice Age(s), reflect global climatic states rather different from those of the present day.

Investigation of the processes involved in these interactions, and of their spatial and temporal scales, will require adequate digital, gridded records of the major cryospheric parameters. For energy exchange studies at the snow/ice surface that involve the atmospheric and the oceanic boundary layers, synchronous data sets will be needed, such as synoptic atmospheric and oceanic soundings, and measurements of horizontal transport.

Data Requirements

In the Climate Program, cryospheric data may be used in:

- Climate research

Boundary conditions for input to models (GCMs and SDMs) (snow/ice, sea ice extent, concentration, thickness, age, surface characteristics needed for albedo and roughness; land ice elevations.)

- Short-term monitoring and prediction of climate and surface hydrology

Daily to seasonal variations in extent, depth, water equivalent, and free water content of snow cover; extent, concentration, and thickness of sea ice; pack ice and iceberg drift

- Long-term monitoring of climate

Climatic fluctuations due to natural and anthropogenic causes, extent and thickness of snow cover, glaciers, sea ice, and permafrost.

- Design/planning assessments

Baseline data on cryospheric variables; cryospheric hazards related to weather and climate (avalanches, icebergs, surging glaciers, jokulhlaups, freshwater or sea ice damage to structures.)

The specific variables and required resolutions, accuracy and frequency of observations are summarized in Table 1 below (modified from WMO, 1976). For some purposes, information with less than the stated accuracy is also useful.

Table 1. Data Requirements for Cryospheric Parameters

Variable	Horizontal Resolution* (km)					Accuracy	Frequency
	A	B	C	D	X		
Snow cover extent	0.3	1.0	3.0	50	1-5	$\pm 5\%$	1-3 day
Snow cover water equiv.	0.1	0.3	1.0	50	1-5	$\pm 10\%$ (3cm)	1-3 day
Snow cover free water	0.1	0.3	1.0	50	--	$\pm 10\%$ (3cm)	1-3 day
Sea ice extent/concentration				50	10-50	$\pm 2\%$	1-3 day
Sea ice thickness				50	--	$\pm 10\%$ (20cm)	1-3 day
Glaciers/ice sheets extent	0.1	1.0	3	50	1-5	$\pm 5\%$	Yearly
Ice sheet thickness, surface elevation	0.1	1.0	3	50	1-5	$\pm 5\%$ (1m)	Yearly
Ice sheet horizontal velocity			Point			$\pm 10\%$ (50m/yr)	Yearly
Permafrost extent	0.1	0.3	1.0	50	1-5	$\pm 5\%$	Yearly

*Drainage basins <100 km² (A); 100-1000 km² (B); >1000 km² (C); Global climate studies (D); Impact Assessment (X)

Data Status

- The major sources of cryospheric data are:
 - snow cover
 - ground observations (synoptic and climate stations, snow courses, special programs)
 - aircraft remote sensing (gamma ray)
 - satellite remote sensing (visible and IR, microwave; composite minimum brightness)
 - coastal or ship observations
 - aircraft reconnaissance and remote sensing (active and passive microwave)
 - satellite remote sensing (visible and IR, active and passive microwave)
 - glaciers and ice sheets
 - ground observations (glacier fluctuations and mass balance, geophysical profiling)
 - aircraft remote sensing (radio-echo sounding)
 - satellite remote sensing (visible and IR, microwave, and laser and radar altimetry)

Satellite data on global snow and ice cover exist since 1966/67, supplemented by ground observations of snow cover or sea ice for tens of years, upwards to a century or more at a few stations, mainly in Europe. These conventional records are not yet centrally available, and most of the satellite data are only in map form. Table 2 summarizes the major national and international data sets on regional to global scales. Ancillary information on surface properties and vegetation types needed for albedo analyses and as modeling inputs are relatively poorly known and are not routinely mapped. Digitization of the basic data sets is just beginning. G. Kukla (Lamont-Doherty Geological Observatory) is preparing snow cover and sea ice and point digital data from NESS and U.S. Navy data. J. Walsh (U. of Illinois) has arctic sea ice concentrations for 1953-77. Other gridded ice data are being prepared by M. Kelly (U. of East Anglia) and K. Hasselmann (Max Planck Institute, Hamburg) from 1901.

Table 2. Summary of Major Snow Cover and Sea Ice Data Sets

<u>Location</u>	<u>Parameter</u>	<u>Period</u>	<u>Source</u>
Global	Snow depth maps	1975	USAF GWC
N. Hemisphere	Snow/ice boundaries and 3 brightness classes	1966	NESS
Global	Composite minimum brightness maps	1968 (format variable)	NESS
U.S.	Depth of snow maps	1935 (Dec-March)	NOAA (Weather and Crop Bulletin)
U.S.	Snow pack water	1930s 1978	SCS, USDA Snotel System
Canada	Monthly snow depth		Environment, Canada
Global	Sea ice limits and concentrations	1970 (Weekly)	U.S. Navy
Global	Sea ice boundary and concentrations (Microwave brightness temperature)	Dec 1972	NASA
Canadian Arctic	Sea ice to 70°N Sea ice to 80°N	1958 Late May-Oct 1960	Environment, Canada
N. Hemisphere	Sea ice limits and concentrations	1960 1957	British Meteorology Met. Inst.

- Archiving

There is no national center for snow and ice data. Most sets of global snow and ice cover data are archived by the (operational) agencies responsible for producing them. These include NESS, NWS, NOAA-ERL, NASA, U.S. Navy, Air Force, and USDA. NCC (SDSB) archives pertinent satellite imagery, and climate records at NCC in Asheville contain much information on snow cover in the United States. Canadian snow cover and sea ice data are being organized into data sets and atlas information by the Atmospheric Environment Service, Canada. World Data Center-A for Glaciology (Snow and Ice) in Boulder, Colorado is currently undertaking an inventory study of snow cover and sea ice data sets.

Glacier and ice sheet data are the focus of the following activities:

(a) World Glacier Inventory being conducted by a Temporary Technical Secretariat of IHP (UNESCO AND UNEP), located in Zurich.

(b) Permanent Service on the Fluctuations of Glaciers (including mass balance data) - data published in three volumes (1959-75), also located in Zurich.

(c) Satellite image atlas of glaciers of the world, being prepared by USGS.

(d) Ice Core Data - currently being inventoried by World Data Center-A for Glaciology.

Data Management Strategy

Cryospheric data exist currently in scattered locations in diverse forms; literature references, hard copy lists (often unpublished) of point data, imagery, and chart series of sea ice and snow cover. In a few selected areas digitization is beginning. However, the immediate need is to develop inventories as a basis for developing data bases. From the standpoint of the Climate Program, the priorities should be as follows for candidate data sets:

- Studies of present climate and physical processes:

Elements
Priorities

Variables
Priorities

Snow Cover

Extent, thickness, water equivalent, water content, surface temperature

Sea Ice	Extent, concentration, thickness, age structure, surface features
Land Ice	Extent, surface elevation, thickness
Permafrost	Extent, active layer depth, thickness

● Studies of climatic change:

<u>Elements</u> <u>Priorities</u>	<u>Variables</u> <u>Priorities</u>
Ice Cones	Isotopes, particles, stratigraphy, chemistry
Land Ice	Extent, mass balance, thickness
Sea Ice	Extent
Snow Cover/ Snowfall	Extent/occurrence
Permafrost	Temperature profiles, extent, thickness

The Climate Program will require gridded data with time resolution as stated in Table 1, especially for snow cover and sea ice. A free format is desirable so that overlay of cryospheric/atmospheric/oceanic/terrestrial parameters in various geographical displays is possible. For climatic change studies, time series of quality-controlled historical records, mainly at point sites, are especially important. The annual records from ice cores are a high priority item. The dating techniques used to establish the chronology are critical.

The use of polar-orbiting satellites to gather data on snow, ice, and sea ice has resulted in an unprecedented accumulation of data. Users requesting ground-based data collections ought to be alerted to the availability of concurrent satellite data.

Recommendations

1. Operational snow and ice chart products should be evaluated and subsequently digitized.
2. The ESMR microwave observations of polar area snow and sea ice should be evaluated, recognizing the valuable property of microwave sensors to penetrate cloud cover.

3. High priority should first be given to continuing the development of inventories for the major variables characterizing global snow cover and sea ice, and, second, to developing digital data bases in grid format. WDC-A for glaciology is already involved in the first state.
4. The new series of 7-day Composite Minimum Brightness (CMB) charts from NOAA/NESS ought to be recorded in digital form at NESS prior to archiving at EDIS.
5. Support must be given to make available geographic data on terrain characteristics, vegetation cover, land use, etc., and data on temperature, radiation, wind speed, etc., that are necessary for studies involving interaction with snow cover.
6. To facilitate international exchange of data, national agencies are encouraged to send data, information, and user requests to the WDC-A for glaciology (snow and ice).

Other specific recommendations are contained in the report "Workshop on Mapping and Archiving of Data on Snow Cover and Sea Ice" (See Glaciological Data, Rpt. GD-5, 1979, in press.)

REQUIREMENTS FOR MODELING SURFACE HYDROLOGIC PROCESSES

As indicated in the National Climate Program - 5-Year Plan, there are five physical ingredients which are fundamental to the hydrologic behavior of a land surface:

1. Atmospheric Evaporative Capacity - the potential rate of evaporation as a function of the gradient in water vapor mixing ratio, of wind speed, and of surface roughness.
2. Evapotranspiration Efficiency - the ratio of actual to potential rates of evapotranspiration as a function of the soil moisture concentration, the hydraulic properties of the soil, and the density and species of vegetation.
3. Surface Temperature - the result of the energy balance in the surface layer.
4. Soil Moisture Concentration - the result of a water mass balance in the vegetal root zone.
5. Runoff - the sum of surface runoff and gravitational percolation as a function of precipitation, soil properties, and soil moisture concentration.

When snow-covered surfaces exist, a sixth ingredient can be added:

6. Density of Ripe Snow - the density of snow (containing the maximum amount of liquid water) as a function of the thermal quality of the snow.

To adequately develop, test, and verify climate models that include a dynamically coupled land-atmosphere system which incorporates the preceding physical constituents, the following kinds of data are needed:

Global Data Sets - (grid-scale averages)

- vegetal canopy density (seasonal variation) ⁽¹⁾
- species or broader biological grouping to differentiate water demand characteristics
- hydraulic and thermal properties of soil
 - effective porosity
 - saturated hydraulic conductivity
 - residual soil moisture
 - thermal conductivity
 - specific head
- albedo (seasonal variation) ⁽²⁾
- surface temperature (seasonal variation)
- snow cover (seasonal variation) ⁽³⁾
- snowpack water equivalent (seasonal variation) ⁽³⁾
- ice cover (seasonal variation) ⁽³⁾
- urbanization density ⁽¹⁾
- cultivated agriculture density ⁽¹⁾
- storm precipitation statistics ⁽⁴⁾
 - storm duration
 - time between storms
 - storm intensity
 - storm depth

⁽¹⁾ Addressed by Working Group 6: Geographical, Land Use, and Assessment Data.

⁽²⁾ Addressed by Working Group 4: Radiation, Physics, and Chemistry

⁽³⁾, ⁽⁴⁾ Addressed by other elements of Working Group 2.

To specifically verify parameterizations, coordinated data sets at grid scale within major river basins are needed. The data necessary are:

- all types listed under GLOBAL DATA SETS
- soil moisture in the surface boundary layer
- streamflow

Data in support of many of these requirements exist in various forms throughout the world. The key issue then is to identify these data sources and in some manner coordinate their availability and retrieval for general use. Also, in view of the large spatial scales involved when modeling on a global basis, the promise of remotely sensed data must continue to be explored. Satellite observations will provide some of the spatial integrations that are necessary for grid-scale parameterizations.

Status of Soil Moisture Data

About 200 soil-vegetation records have been uncovered in a recent survey of available soil moisture data. They include several studies mainly at SEA-AR research stations scattered throughout the United States. A 5-year soil moisture pilot study is proposed by the Soil Conservation Service (SCS) in cooperation with SEA-AR and State Agricultural Experiment Stations.

Soil moisture and climatic data are used in the SPAW soil moisture model to predict soil water consumption by various crops during the growing season. The major data requirements of this model include the following:

- daily rainfall
- open pan evaporation
- daily net radiation
- daytime wind travel
- weekly soil moisture (for development and verification)
- estimated rooting depth

Hydraulic and Thermal Properties

Data that provides measurements of effective porosity, saturated hydraulic conductivity, and residual soil moisture

are available in many technical publications, but generally have not been made a part of a national data base. Much of the research has been done independently by university and Federal researchers. Data generated at the National Soil Survey Laboratory in recent years have been stored in a soil data base system. Major needs for these kinds of data can best be identified only when the available data are made a part of a data management system.

Data on thermal conductivity of soil-water systems and surface temperature (seasonal variations) are very limited. Coordinated data sets in major river basins are needed.

Recommendations

Several Federal and State agencies are independently undertaking the tasks of digitizing soil survey maps, and construction of computer-oriented soil data base systems. The purpose, scope, and execution of each agency's efforts are varied, as are the levels of financial support. Therefore, to optimize the utility of soils data to the National Climate Program, the working group recommends a coordinated national emphasis on the development of soil data base management systems. No new data collection programs are proposed by this recommendation. Rather, existing information found in tabular and map form should be digitized and formatted for interactive availability. Additionally, the soil from which data have been acquired should be properly classified before the data are archived. Soils data from local, regional, and international sources should be included as soon as they are validated.

It is recommended that the USDA take the lead role in this effort.

Soil moisture is a critical component in establishing a statement of water balance in the land surface boundary layer. Therefore, it is recommended that time series of soil moisture data be centrally archived and made available for general use through interactive computer systems.

It is recommended that the USDA take the lead role in this effort.

Recognizing the difficulty in obtaining useful soil moisture information on a global basis, it is further recommended that the National Climate Program Office be a focal point for coordinating and sponsoring research programs for the continued development of technologies to remotely sense soil moisture data on an international scale.

OCEAN EVAPORATION

Data Requirements

There is little likelihood of direct measurement of evaporation over the world oceans in the foreseeable future. Rather, parameterization methods, using ship deck level vapor pressure and wind speed, and sea-surface temperature will continue to be the prime method for obtaining routine estimates of oceanic evaporation. The time/space resolution of these data should be adequate to resolve synoptic scale atmospheric variations. The most stringent requirement for sea-surface temperature observations is the resolution of the strong gradients in the neighborhood of the Gulf Stream and Kuroshio.

General Status of the NCC Marine Data Base

Currently, the data for estimating oceanic evaporation is derived primarily from surface ship observations, i.e., the Marine Data Base.

The Marine Data Base at NCC is one of the most complicated and least organized of all NCC files. Problems associated with marine files stem from a number of factors. Enthusiasm and support for marine data has been sporadic. In 1973, after a major funding effort to produce an updated marine atlas, the Navy terminated funding and as a result data on forms began to pile up in boxes. In 1976, the Navy and NOAA jointly renewed support of marine data processing but on a much smaller scale.

In order to have as complete a file as possible, NCC obtains marine data from numerous sources including NMC, the U.S. Air Force Global Weather Central, the Navy, and foreign countries. This means that NCC must eliminate duplicate observations from all of these sources. It also means the NCC is receiving observation months and even years after they are taken.

There are over 1,500 tapes in the marine file and nearly 300 in what NCC terms its main library. Because the main library data are sorted by area, all 300 tapes must be mounted when new data are received for all areas.

The best and most comprehensive marine files are the so-called Marine Atlas Files (generated for the Navy) and the Historical Sea Surface Temperature (HSST) File. The Atlas files cover the following periods for each ocean:

North Atlantic	1850-1972
Indian	1850-1973
North Pacific	1850-1974
South Atlantic	1850-1976
South Pacific	1850-1978

The HSST File contains bucket SST observations for 1860-1960. HSST processing for the Atlantic Ocean has not yet been completed.

Availability of Data to Compute Evaporation

To compute evaporation from the oceans, the bulk aerodynamic equations can be used provided air temperature, wet bulb temperature, and wind speed are available for ship deck levels and the sea-surface temperatures are also available. No comprehensive inventories of the observation variables exist. However, temperature, wind speed, and sea-surface temperature observations are generally available in all observations going back to the late 1800s. When NCC produced a marine atlas in 1954 based on observations from before 1900 to 1952, only 14 percent of the observations contained wet bulb temperatures, and a cursory check has shown that most of these occurred after 1940.

When NCC produced another marine atlas in 1973, the percent of observations containing wet bulb temperatures increased to approximately 45. These statistics provide no information on the quality of the observations.

Data Management Strategy

The NCC has set up a task team to design a new data processing scheme using the systems analysis approach. The processing scheme will be used to reprocess historical marine files as well as incoming data. The NCC hopes to eliminate the numerous marine files now in existence and to create two cleaned up files, one in a synoptic sort and the other in an area sort. At the same time detailed inventories will be generated to the element level about quantity and quality.

Because this is viewed as a 3- to 5-year task at a time when the data are needed, an intermediate objective is being defined. The marine atlas files represent a relatively good data base for the period from the 1850s to approximately 1973. From 1973 to the present, the data are in several files which cannot readily be used to service customers. For this reason, the NCC plans to process and merge the data in this latter period first in an attempt to provide marine data which compliments the pre-1973 data.

ATMOSPHERIC HYDROLOGIC DATA

INTRODUCTION

The vital common element of hydrology and meteorology is water. Both sciences are concerned with synoptic observations of water in its various forms, and with the movement and phase changes of water through natural processes. The transfer of water at the air-surface interface is of prime concern to both hydrologists and meteorologists. A similar common interest between oceanographers and meteorologists exists at the air-sea interface. Evapotranspiration serves as an all-important "input" to the atmosphere in the determination of weather and climate, while representing "output" or water loss from the hydrological or oceanographic point of view. Conversely, precipitation is atmospheric "output" while representing the replenishment of the water resource to hydrologists. It therefore seems clear that consideration of the continents, oceans, and atmosphere as interacting components of a single system is fundamental to a basic understanding of the role of the global hydrological cycle in climate and climate change.

The equation for the water balance of the earth, which is derived from the more general statement of the continuity of water substance, has served as a central concept for hydrologists. A similar equation can be derived for the water balance of the atmosphere. During the past few decades an improving network of aerological stations has produced progressively more detailed and accurate measurements of the various terms of this balance equation. It has been clearly demonstrated by a number of studies that the atmospheric water balance can be accurately evaluated, but the smallest areas and shortest time periods for which useful computations can be made are determined by the density of observation stations, the accuracy of observations, the frequency of sampling, and the local terrain.

DATA STATUS

Atmospheric Moisture Flux Computations from Rawinsonde Data

The potential use of satellite data for the evaluation of the atmospheric water balance will be discussed in the next section. However, it appears that rawinsonde measurements of wind and humidity will continue to serve as the primary data source for atmospheric moisture and moisture flux

computations over the land areas of the earth for some time to come. The operational rawinsonde network is primarily designed to resolve synoptic scale (1,000 km) meteorological features. This spatial resolution is compatible to that of existing general circulation models of the atmosphere. The operational hydrologist is primarily interested in basins smaller than 10^5 km²; scales which cannot be adequately resolved by the rawinsonde network. Nevertheless, the larger scale studies can provide information useful in the calibration of empirical relationships which can in turn be applied to the smaller basins.

The network of operational aerological stations over North America, Eurasia, and Australia is adequate for a number of important studies involving the atmospheric branch of the hydrologic cycle. The upper air network over the remaining areas of Earth severely limits the range of studies which can be undertaken. Some improvement in this situation can be expected for the augmented network of global observations during the current Global Weather Experiment.

Recent field experiments, which began in 1969 with the Atlantic Tradewind Expedition (ATEX) and the Barbados Oceanographic and Meteorological Experiment (BOMEX), provide data for a new generation of atmospheric water budget studies. Unlike data from the routine operational network, the field experiments were carefully designed to provide data for meaningful budget computations over relatively small areas, and short time periods. Specifically designed or calibrated instrumentation was used, and observational arrays and schedules were tailored to provide answers to the specific problems under investigation. Rawinsonde observations are sometimes augmented by aircraft observations and data from special boundary layer observational systems. Although of limited extent in both time and space, these special data sets provide useful information on many aspects of the atmospheric hydrologic cycle.

A number of important problems must be carefully considered when developing a rawinsonde data base specifically tailored to the rigid requirements of atmospheric water balance computations:

1. The accurate evaluation of the atmospheric water balance requires relatively high vertical resolution of the specific humidity and wind profiles in the lowest few hundred millibars of the atmosphere. Data only at the mandatory reporting levels (1,000 mb, 850 mb, 700 mb) are often inadequate for these computations. Fifty or even 25 mb resolution is sometimes required from the surface to 900 or 800 mb to define the profiles. The 5-year MIT data set, which has been the data source for many

of the global scale water balance studies, consists of data at 50-mb intervals for Canadian and United States controlled stations, but only mandatory level data, without surface observations, are available for most of the remaining stations. Efforts have been made by some investigators to supplement these data with low altitude climatological data.

2. The monthly average values of aerological humidity parameters included in the MIT data base were computed as averages of the available observations during the month. Thus a station average for any particular month may be based on anything from a few observations to a full set of observations. Since hydrological events have a highly non-uniform distribution throughout the month, e.g., the major vapor flux convergence may be associated with two or three major precipitation events, the lack of a full set of observations may lead to significant errors in individual monthly values. In order to obtain accurate monthly values, it is necessary to begin with relatively complete station data sets, and apply methods of interpolation for observations which are missing.
3. Prior to the 1960s, operational rawinsonde humidity measurements exhibited known deficiencies. The change of U.S. rawinsonde humidity sensors from a lithium chloride to a carbon element in the early 1960s was expected to significantly improve the quality of the observations, but deficiencies in the design of the rawinsonde package, not discovered until the late 1960s, led to significant errors in humidity measurements during ascents when the instrument was exposed to direct sunlight. Thus, the daytime observations from U.S. or U.S.-controlled stations are of uncertain quality during the period when this instrument package was in use (early 1960s - 1970).

Documentation of and adjustment for data biases such as this is critical if atmospheric vapor flux data are to be effectively used in climate studies.

Application of Satellite Products

Two types of meteorological satellites currently provide operational products and research data for a wide variety of users. Geostationary satellites are positioned over the equator at a fixed point above the Earth's surface. Polar orbiting satellites are in sun synchronous orbits, with periods of slightly less than 2 hours. Operational meteorological satellites currently provide remote sensing of the atmosphere in the visible and infrared, and Nimbus experimental satellites provide remote sensing of the atmospheric in the infrared and microwave portions of the electromagnetic spectrum.

Wind Estimation

Imagery from geostationary satellites have provided meteorologists with a method for estimating winds from satellite data. Several pictures taken during the lifetimes of trackable cloud patches are used to obtain cloud motion vectors. To the extent that these clouds are advected by the wind, the method provides an estimate of the wind velocity at cloud level.

Since the geostationary satellites are positioned over the equator, computations of this type are generally limited to a 35-degree latitude band on either side of the equator. Within this latitude band, computations have generally been limited to two levels: (1) a low level at which the cumulus patches can be used as tracers and (2) a high level, at which cirrus can be used as the cloud tracer.

The accuracy of these wind estimates has been difficult to assess due to the lack of adequate "ground truth" with which they can be compared. However, a recent study by Hubert and Thomassel indicates that NESS winds computed from low level cloud vectors contain errors of 4.7 m s^{-1} . Use of more sophisticated methods can, however, reduce the errors. Nevertheless, this method has a number of features which limits its value in providing wind data for vapor flux computations. These factors are enumerated below:

1. Vertical resolution

As previously discussed, a minimum vertical resolution of 50-100 mb is required for vapor flux computations. The cloud motion vectors provide data for vapor flux computations primarily at a single low level, since the cirrus level winds are too high to be of much practical value in vapor flux computations. In the past, when only picture data were available, it was difficult to determine even the height of the clouds, i.e., the level to which to attribute the motion vector. This situation has improved considerably with the inclusion of infrared sensors on the SMS satellite, which can be used to determine cloud top temperature, and thus, indirectly, cloud height. Using these data, it may also be possible to derive some additional cloud motion vectors at different levels near disturbances.

2. Biased statistics

Computations are obviously made over areas where tracer clouds can be observed. For instance, good low level cloud tracers frequently cannot be discerned within

disturbances, where middle and upper clouds obscure the lower layers. As a result low level cloud vectors are derived only in undisturbed areas, and on the periphery of disturbances. Such observations, interpolated across the active portion of disturbances, may severely underestimate the intensity of the system, and lead to large errors in the computed divergence field. Thus, increasing the density of cloud vector computations does not necessarily increase the meteorological information in disturbed areas.

3. Random sampling

Coupled with the biased sampling discussed above is the general problem which random sampling introduces in the computation of statistics for a fixed drainage basin. Random observations are difficult to summarize without accumulating grid point statistics from a map analysis for each observational time.

Our conclusion is that data derived from this method of wind estimation, in its current state of development, is of secondary value for vapor flux computations. Even when used as supplementary data at a single low level, the additional wind estimates may do more harm than good if they result in a biased sampling of synoptic conditions. This statement in no way reflects on the value of these wind estimates for defining the low level synoptic patterns for more general meteorological analyses over data-sparse areas.

Humidity Data

Estimates of specific humidity can be obtained from infrared data, and estimates of both liquid water and water vapor can be obtained from microwave data currently being collected from polar orbiting satellites. These measurements are made by vertical sounders, which are basically instrument packages designed to measure radiances in a number of spectral regions corresponding to various layers of the atmosphere. The measurements can be used to derive atmospheric temperature and moisture profiles of the radiating columns. Instrument packages currently in orbit scan only a finite distance across the orbital track, resulting in gaps at low latitudes between successive orbital passes. The satellite radiance measurement is closely related to the total integrated water vapor content of a volume of atmosphere several kilometers in both the horizontal and vertical dimension. On the other hand, the radiosonde measures the water vapor content of small parcels of the atmosphere. Although the radiosonde is capable of giving

much higher vertical resolution than the remote satellite sounder (meters compared to kilometers), the satellite sounding system has the potential for achieving much higher spatial resolution and more meaningful horizontal gradients than that achievable with the current operational rawinsonde network. The fact that the same instrument observes at all geographical locations contributes to the relative accuracy of the satellite.

The observational systems and computational techniques currently in use appear to be sufficient for computing only the vertically integrated water vapor content to a reasonable degree of accuracy. Even then, problems arise in the use of infrared data for this purpose in the presence of clouds. On the other hand, microwaves are unique in their ability to yield measurements of tropospheric water vapor in the presence of clouds. Unfortunately, because of the high emissivity of the land surface, the use of passive microwave radiometry is limited over land.

GENERAL DATA MANAGEMENT STRATEGY

Data Types

To build a data base specifically designed for evaluating the atmospheric hydrologic cycle, the following types of atmospheric data should be routinely archived:

- Rawinsonde data
 - wind, temperature, and humidity; surface to at least 300 mb; 50 mb vertical resolution highly desirable, but decreased resolution acceptable above 700 mb.
- Surface synoptic meteorological data
 - at least 6-hourly resolution. Wind, temperature, humidity, surface pressure, cloud cover, weather, and precipitation amount.
- Satellite data
 - derived humidity and wind data as available.

Quality Control

Past experience has demonstrated the necessity of quality control over the above, exercised on the operational data

when these data are to be used for computing sensitive, derived quantities such as vapor flux divergence. It is senseless to expend large amounts of money on processing and storing atmospheric hydrologic data whose reliability is questionable and whose utility is correspondingly compromised. A well-conceived and implemented program of data validation may spell the difference between success and failure for many applications.

This validation should include the following subtasks:

1. Maintenance of a historical documentation file which includes for each observing station:
 - (a) A station description, including a description of the type of instrumentation used and the period during which it was operational. The description should include the data characteristics and data collection rate, and the associated methods of processing.
 - (b) Results from intercomparison programs.
 - (c) Description of normalization adjustments applied to data from each sensor or system type.

The maintenance of a file of this type and the proper normalization of current data requires a continuous monitoring of the observational network for changes in instrumentation, changes in procedures, or changes in exposure or station location. The file should serve as a part of the basic data documentation and be available to the individual investigator.

2. Gross quality control analysis of the basic data in order to identify and flag or correct obvious errors.

The basic data archive should include the normalization adjustments. These should be included in a manner which gives the user the option of applying them, or modifying them in the light of later studies and information.

CONCLUDING REMARKS

The most general application of vapor flux data is in the routine computation of regional water balances, and the subsequent development of monthly, seasonal, and long-term regional water balance climatologies. In their most complete form these computations consist of the simultaneous evaluation of the individual terms of the terrestrial and atmospheric water balance equations in order to obtain estimates of area-averaged evaporation and total surface and subsurface storage change.

The accumulation of these basic data and derived data products results in a data base of considerable value. A multi-year data base of this type can be used for such diverse projects as (1) examination of the variability of the hydrometeorological parameters and its relationship to such problems as drought, precipitation augmentation, and other water supply problems; (2) development of hydrologic and heat balance models, including the development, testing, and calibration of empirical methods for estimating areally averaged evapotranspiration; and (3) base-line data for environmental impact and climatic change studies.

The use of atmospheric flux data for projects with more limited objectives may often be desirable. Examples of such studies are:

1. Evaluation of the magnitude of the suspected negative bias in the values of "measured" precipitation. Cases would be selected for which the error in estimation of the areally averaged evaporation would be a small percentage of the total precipitation. Examples would be composite balances computed from data covering a number of short periods spanning major rainstorms, or periods of heavy snowfall.
2. Estimates of regional snowpack. Computations of this type may be of value for major mountain areas or remote regions for which there is an adequate distribution of rawinsonde stations on the perimeter. Reasonably accurate independent estimates of evapotranspiration during the winter season are required for these computations.
3. Evaluation of the atmospheric water balance over oceanic regions or large inland water bodies which exert a direct effect on the hydrology of the adjacent region, e.g., Sea of Japan, Great Lakes.

Within the framework of current World Weather Watch (WWW) observational programs, the rawinsonde remains the primary observational tool for obtaining the humidity and wind data required for the computation of the vapor flux and vapor flux divergence. Rawinsonde data are typically archived only for the mandatory levels, i.e., 1,000, 850, 700, 500 mb... . The accurate evaluation of atmospheric water balance quantities often requires a surface observation, and at least a 50-mb resolution of the wind and moisture profiles in the lowest few hundred millibars of the atmosphere. The use of these data is further complicated by the existence of system biases in the moisture measurements, which creates difficulties when using data acquired by a number of different national measurement systems. A well-known example is the negative bias in the daytime humidity measurements obtained from the U.S. rawinsonde in use during most of the 1960s.

In the current "state of the art," meteorological satellite products appear to be of value for obtaining estimates of total water vapor content, but appear to be of marginal value for vapor flux computations. Their major shortcomings at this time are inadequate derived wind data, and inadequate vertical resolution of the humidity profile. Progress continues in this field, and continuing research in the application of satellite data to atmospheric water balance computations should be monitored and encouraged.

RECOMMENDATION

The operational rawinsonde network continues to provide the basic moisture and wind data for evaluating the atmospheric hydrologic cycle. Because of special data problems and requirements, the currently archived rawinsonde data is often inadequate or only marginally adequate for these computations. In order to overcome the major shortcomings, it is recommended that (1) the corresponding surface observation be archived with the upper level data; (2) data be regularly computed, transmitted, and archived at 50-mb intervals, at least for the layer below 850 mb; and (3) documentation of instrument type, including humidity element, known biases, and established methods for correcting the data be included as an integral part of the rawinsonde data archive.

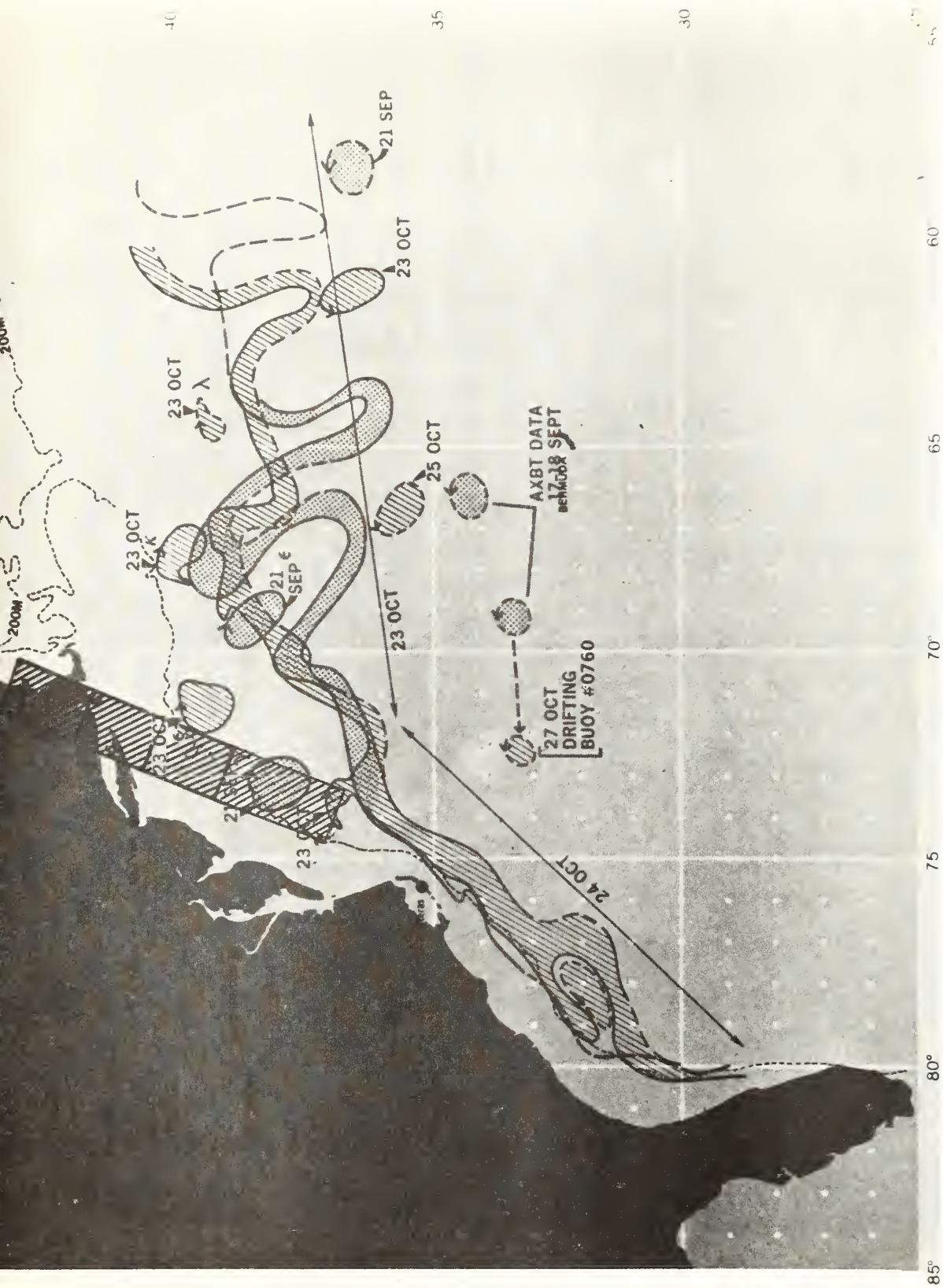
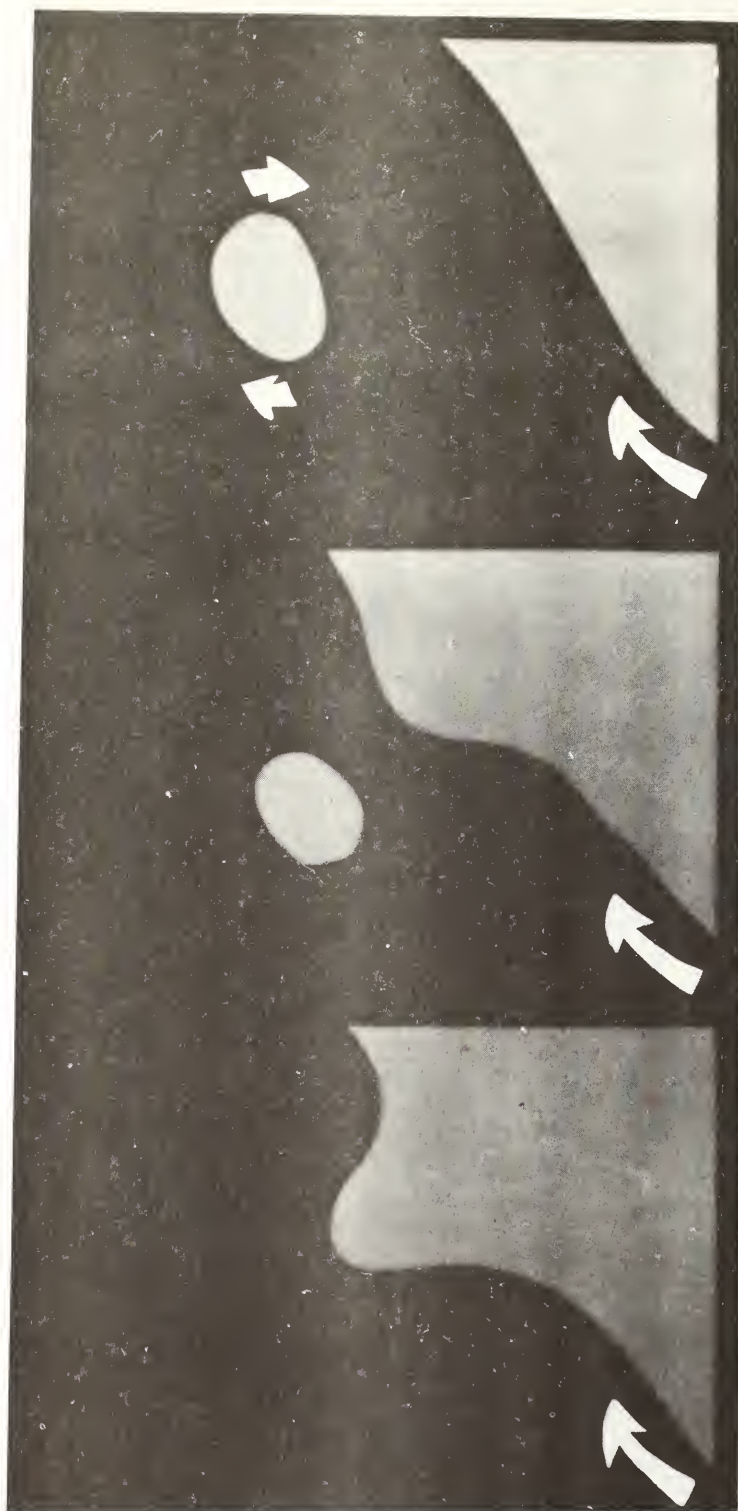




FIGURE 2a. NASA Seasat S.A.R. composite imagery showing the variability in the course of the Gulf Stream and the shedding of vortex cores. Such information is valuable to physical oceanographers and to commercial fisheries. October 1978



KEY:  SARGASSO SEA

 SLOPE WATER

 GULF STREAM

*TYPICAL DIAMETER OF A RING: 100-200 KM.
SURFACE CURRENTS: 50-100 CM/SECOND.*

NASA HQ 179 2784 (3

FIGURE 2b. Genesis of a warm core ring.

OCEAN DATA

Working Group 3

Chairman: Kent Hughes

Members: James Churgin
Philip Cohen
Wayne Darnell
Steacy Hicks
Merton Ingham
Sydney Levitus
Douglas McLain
Stephen Pazan
Robert Quayle
Vince Zegowitz

SUMMARY

The Ocean Data Working Group was comprised of ocean data users, data managers, and data generators representing several U.S. government agencies and a single academic institution. The group considered the influence of oceanic conditions, both surface and subsurface, on atmospheric climatology and the effects of varying atmospheric climate on ocean processes. It was felt by a minority of the group that the climate of the ocean itself is important and should be a part of the NCP. Certain data types comprising general categories of oceanographic parameters (noted in Table 1) were suggested for consideration by the group from the standpoint of relevance to the objectives of the U.S. Climate Program. Important climatological aspects of each data type are described in the following material. The group prioritized each data type with respect to the objectives of the U.S. Climate Program. The data needs under each category were considered, keeping in mind their relevance to assessment and application functions. Data types of broadest interest were: Surface Marine, Subsurface, and Ocean Current data; priority rankings are indicated in Table 1.

TABLE 1
RELATIONSHIP OF MARINE DATA MANAGEMENT PRIORITIES
TO NCP PROGRAM OBJECTIVES*

	IMPACT ASSESSMENT NO'S			RESEARCH					DATA INFORMATION, SERVICES				PROSPECT
	1d	1h	1i	1a	1c	2a	3b	3c	1.2b	2a	3b	3e	
Surface Marine													High
Subsurface Ocean Data	1d	1h		1a	1c	2a	3b	3c	1.2b	2a	3b	3e	High
Currents	1d	1h		1a	1c	2a	3b	3c	1.2b	2a		3e	Med-High
Time Series Ocean Data	1d			1a					1.2b	2a	3b	3e	Medium
International/ Foreign Exchange		1h					3b	3c	1.2b	2a		3e	Medium
Remotely Sensed Ocean Data	1d	1h						3c	1.2a	1.2b	1.4a	2a 3e	Medium
Fisheries Data	1d		1i						1.2b	2a		3e	Medium
Sea Level	1d		1i		1c				1.2b	2a	3b	3e	Medium
Bathymetry	1d	1h					3b			2a			Low

*Task numbers as identified in Chapter 3 of the Draft Preliminary 5-Year Plan, National Climate Program, April 20, 1979.

Key: Climate Impact Assessment

- Task 1d - Biological response models related to marine fishery production
- 1h - Climate impacts related to military systems and strategies
- 1i - Studies related to climate impacts of societal concern

Research

- Task 1a - Improve historical data sets
- 1c - Interactions between climates in geographical location
- 2a - Ocean heat storage, transport and atmospheric coupling
- 3b - Develop ocean models
- 3c - Develop coupled ocean-atmosphere climate models

Climate Data, Information and Services

- Task 1.2a - Satellite system for global coverage of sea-surface temperature, sea-level (topography), and wind stress
- 1.2b - Expand in-situ ocean monitoring
- 1.4a - Satellite measurements of polar ice
- 2a - Prepare data sets that will have broad use and enhance availability of implied information
- 3b - Diagnose recent and current climate fluctuations
- 3e - Continue and expand statistical descriptions

RECOMMENDATIONS

Recommendations made by Working Group 3 are felt necessary to achieve National Climate Program goals.

Surface Marine Data

- Primary

- Digital data from Surface Marine Platforms (primarily ships) for the period 1973 to the present require consolidation, validation, duplicate elimination, and compaction into forms that are readily accessible and updatable by geography time and in platform sequence. The data should be inventoried by space, time, platform, and element. NCC will perform this work.
- Work similar to the above recommendation should be completed for the period 1850-1971. In addition, foreign digital data that are not presently in the archives should be surveyed, selectively acquired, and included.
- U.S. data prior to WW II, which are mostly undigitized, should be inventoried, selectively digitized, and processed through the steps included in the first recommendation above.

- Secondary

Recognizing the importance of Sea-Surface Temperature (SST) and certain other data elements to remote sensing calibration as well as direct NCP needs, it is recommended that:

- Efforts should be increased to selectively obtain ship data from data-sparse areas;
- Acquisition and archival of data from fixed buoys, drifting buoys, and satellite remote sensing systems should be stimulated.
- Further development and use of automated data acquisition systems (such as SEAS) and automated satellite data collection systems should be encouraged to improve the quality of ship-of-opportunity data.

Subsurface Ocean Data

- Historical data from WDC-A for Oceanography should be processed by the National Oceanographic Data Center on a selective basis to fill time and geographical gaps in the record; accelerated accession of data for these gaps should also be encouraged.
- Newly developed quality control procedures must be applied to data in the NODC to assure high quality data sets.
- Compressed data formats must be developed and adopted at the NODC for improved accessibility of data.
- With respect to C/STD data, uniform formats must be adopted and definite processing procedures must be followed at the NODC.

Currents

- For the derived surface current file (SCUDS), an on-line inventory should be developed to improve accessibility to those data.
- Contemporary data should be added to the SCUDS file. Those data added must have good geographic registration.

Time Series Ocean Data

- In light of the paucity of time series ocean data, a feasibility study should be undertaken to examine establishing synthesized nearshore subsurface oceanographic time series of measurement sequences for a period of record of greater than 20 years.

International/Foreign Exchange

- Relevant international groups, i.e., IOC, WMO, UNEP, and others, should support efforts to exchange ocean data in uniform accepted formats.
- A comprehensive inventory system should be supported -- like the Marine Environmental Data Inventory Data System (MEDI). Such a system is being undertaken for the FGGE year by the RNODC - FOY.

Remotely Sensed Ocean Data

- In light of the great cost associated with processing this type of data and the great amounts of data generated, dedicated support should be provided for insuring proper processing, archiving, and retrieval of these data sets.

Fisheries

- An inventory should be conducted of all fisheries data held in archives and elsewhere.
- A special effort should be made to identify and acquire long time-series of year class strength data; and information on bio-environmental linkages for major species. The identity of biologists cognizant of the strengths and weaknesses of the data should be recorded and climate-fisheries analyses must not be undertaken without expert fisheries biological assistance.

Sea Level

- Attempts should be made to develop better sources of international sea level data. Concomitantly provisions should be made for domestic archival and servicing of this data type.

Bathymetry

- An inventory of U.S. holdings of bathymetric data will aid in the selective accessioning and processing of such data in data-sparse areas and in areas of critical need.
- Request from researchers and modelers an expression of the minimum density of observations per unit area of ocean bottom necessary for climatic modeling purposes.

CONSIDERATION OF DATA TYPES

Introduction

There are a number of needs for oceanic data. The oceans as a component of the Earth's climate system appear to play a major, if not totally determined, role in the annual and inter-annual variability of our climate. Specifically, the ocean plays a major role in the Earth's heat balance, acting as a medium for both storage and transport of heat. Climate researchers are presently using observed ocean data in the following ways:

1. For diagnostic studies of the Earth's heat balance in conjunction with atmospheric and radiation data.

2. Verification of numerical and analytical models simulating the Earth's climate. Once the annual cycle of the Earth's present climate can be reasonably simulated then sensitivity studies such as the effect of increased CO₂ on climate can be conducted with greater accuracy.
3. Use in diagnostic numerical ocean models. Because of computer time required for integrating numerical ocean models to an equilibrium state, analyses of observed temperature and salinity data as well as climatological wind stress data are used as driving forces to speed up equilibrium. Model predicted velocity fields are then used for studies such as simulating observed tracer distributions such as tritium. Once reasonable simulations are achieved the models can be used for simulating oceanic transport of other climate related variables such as CO₂.
4. Use in understanding and parameterizing relevant climate related processes such as mixed layer dynamics.

Climatological ocean data provides environmental baseline information for engineering design criteria, long-range event planning, feasibility analysis, and impact assessment. Examples are outer-continental shelf environmental assessment programs; design of ships based on ocean wave climatologies; and design of marine structures based on storm, ocean current, wave distribution, and thermal conditions.

Other uses include the study of climatic scale variability of living marine resources and pollution studies.

Considering these needs and the objectives of the U.S. Climate Program for ocean data, several data types were addressed:

- Surface Marine Data
- Subsurface Ocean Data
- Currents
- Time-Series Ocean Data
- International/Foreign Exchange
- Remotely Sensed Ocean Data
- Fisheries Data
- Sea Level
- Bathymetry

Focusing on each of these data types, the following questions were posed.

1. What data are needed?
2. What data can/should be obtained from other working groups within the working group?
3. What is the present status of this data type?
4. What is the accessibility of this data type to prospective users (both data and products); including ease of access, cost, inventory of data and products, etc.?
5. How well does this data type fit known user needs, both present and projected?

Surface Marine Data

Surface marine data considered essential to the climate program are as follows:

- (a) Remotely sensed - winds, ocean currents, ice, SST, clouds, waves, precipitation radiant fluxes
- (b) Surface platforms: Primary - SST, winds, air temperature, humidity
Secondary - Clouds, waves, precipitation, sea level pressure

Data needs from Working Groups 1 and 2 should be considered when discussing ocean data.

User groups are primarily scientists interested in time series or long-term analyses for climatology and engineers whose main concerns are usually long period studies of small geographic areas.

For the remotely acquired surface data, accessibility is adequate for sea-surface temperature and clouds. However, some improvement is needed in sea-surface temperature accuracy. Definite improvements are required for elements as this relates to accessibility. With respect to data acquired from surface platforms, the need is recognized for accessible, validated surface data, primarily SST, wind, air temperature, and humidity -- secondarily, cloud, wave, precipitation, sea level, pressures and other miscellaneous elements that are collected for operational meteorology. The highest priority should be to organize available digital files.

1. Organize the U.S. International Digital Data Set for the period 1973-present.

2. Organize the U.S. International Digital Set for the period 1850-1973.
3. Punch and organize U.S. Data for the period prior to WWII, most of which is presently unprocessed.

Recognizing the large gaps in data coverage away from the major shipping lanes, data from fixed buoys, drifting buoys, and satellite remote sensing systems are recognized as essential.

With respect to the accessibility of data, cost for processing unprocessed or partially processed data is an essential limiting factor. Availability of the data as reflected in the above paragraph is also a problem, as are gaps in time and space. A thorough search of available surface data from worldwide sources should be conducted.

With respect to user needs, derived products should be established and maintained, preferably using objective analysis techniques, to assure space and time continuity. Temperature, SST, wind, clouds, surface fluxes, wind stress, and pressure should be included. Selected time series should be produced as well as products for large scale, long-term climatology. These data are of vital importance to the National Climate Program as they represent the major avenues by which energy and momentum are exchanged between the oceans and atmosphere. Knowledge of these processes is necessary to support efforts to forecast climatic variations.

Subsurface Ocean Data

Various types of subsurface ocean data are required for climate purposes. Some of these data types are: water temperature, salinity, dissolved oxygen, and nutrients. These data are for a variety of purposes, including (1) mapping of ocean conditions; (2) computation of ocean currents, heat content, and advection; and (3) study of biological productivity. Such data have been collected for over 100 years and constitute a major source of our knowledge of the ocean, its currents, and its variations. Particularly important to the climate program are variations of major ocean currents and the variable amounts of heat they transfer from tropical to temperate region.

Traditionally, subsurface ocean data were taken from Nansen bottle casts, but in the last 30 years sophisticated profiling instruments such as mechanical BTs and STD instruments have become available. In the very recent past, expendable profilers such as XSTDs have been available. Also in the past these missions were commonly made from research vessels. Recently, to contain escalating research vessel costs, many measurements are now made from platforms of opportunity such as merchant ships or moored buoys.

Ideally, users need such data on various scales of spatial resolutions. For global climate modeling one would like adequate data in every part of the world ocean. As noted previously, available data is sparse in mid-ocean areas, particularly in the southern hemisphere. Thus a need exists for more data in tropical and southern hemisphere areas. Intensive sampling of XBTs from merchant ships is now available in the North Pacific and off the east coast of the United States.

In certain selected areas, we want more frequent, more closely spaced observations than the above global dispersion of observations. More concentrated observations are desired in waters near the United States. An inexpensive means of monitoring major ocean currents is possible by taking repeated XBT sections from ships of opportunity in lines normal to such currents. Such repeated XBT sections can be made monthly or more frequently.

<u>Location</u>	<u>Ocean Current</u>	<u>Period of Record</u>	<u>Organization</u>
New York to Bermuda	Gulf Stream	1970-1975	NAVOCEANO
New Orleans to St. of Florida	Loop Current	1970 to Present	NMFS
San Francisco to Honolulu	California Current	1966 to Present	NMFS (NSF)
Honolulu to Tahiti	Equatorial Current	1972 to Present	NMFS-Univ. of Hawaii

We suggest other nations could do similarly in waters of interest to them. For example, the French are starting such sections between Japan and New Caledonia across the Kuroshio.

Relative to Question 4, data obtained from other working groups are not applicable.

The prime area repository of this type of data is the National Oceanographic Data Center; its holdings are generally good. There are areas of sparse or non-existent coverage. But efforts should be taken, however, to fill in gaps in areas and/or time periods of prime interest to be decided by project personnel. Additional data could come from foreign sources, but problems exist in format diversity, medium of exchange, and the expense of entering data into our system.

For existing domestic files, the access is good with response times usually on the order of days to weeks. For foreign data, however, the cost of obtaining and/or reformatting such data is often significant. Access is good to station data via NODC, but access to C/STD data is very poor. Better means are needed to support efforts to get C/STD data from institutions and in through the National Oceanographic Data Center. It was noted that Fleet Numerical Weather Central is now merging NBT, XBT Hydrographic Cast Data, STD and Message Data. It was suggested that NODC and FMWC use similar formats to inventory and store data.

Subsurface ocean data sets are directly related to the need for the following National Climate Plan tasks as described in the Draft System Plan. Climate Impact Assessment Tasks 1d, 1h; Research Tasks 1a, 1c, 2a, 3b, 3c; Data Information and Services Tasks 1, 2b, 3b and e.

Numerous problems exist with subsurface data:

1. Data at NODC are accessible by existing programs, but user cost and convenience will be considerably aided by compression and quality control of the data.
2. Better coverage is required in southern tropical oceans.
3. Potential problems exist with calibration of XBTs below 400 meters.
4. More salinity data is needed to better understand density structure and hence ocean currents.
5. Deep currents below 1,000 meters need to be studied for understanding of reservoir of carbon dioxide in oceans.
6. Cost effectiveness of digitizing pre-1954 mechanical BTs should be investigated.

Priorities must be set for selective accession of data in areas of sparse data coverage and/or converting available but unautomated data into accessible form. General oceanographic files need general housekeeping for quality control purposes. Chemistry components of station data files must be examined for errors.

Currents

Surface and subsurface currents needed for climate purposes include derived surface currents from ship set and drift observations (SCUDS data sets), drifting buoy observations measured subsurface current meter observations and in the future, tomography.

Processes of major importance in climate studies are the exchange of heat between the ocean and the atmosphere and the transport of heat between the tropics and temperate regions by ocean currents. Observations of ocean currents by direct means are possible using drifting buoys, current meters, and by the drift of ships from a fixed course. Normally, the direct observations are too sporadic in time or space and indirect measures of ocean currents (such as geostrophic transport computations from temperature and salinity data or Ekman transport computations from wind and pressure data) must be used.

The derived surface current data set from ship set and drift observations is reasonably well organized. Data and summaries are programmed and available but without an on-line inventory -- only hard copy is available. Data is sparse outside of shipping lanes and data is of low quality for individual observations. Subsurface current data sets suffer from widely differing formats, differing observational standards, and highly varying degrees of quality. The National Oceanographic Data Center (NODC) has data sets from national and international programs and maintains a detailed inventory of U.S. data. There is a need for screening individual data sets and for incorporating those of apparent good quality into a uniformly formatted, easily retrievable quality control data set.

Accessibility to the SCUDS file is good except that a detailed on-line inventory is not available. Both data and standard products, however, are available. The subsurface current data, for the most part, is costly and difficult to use due to the lack of uniformity in data formats.

Ocean current data are needed for the following tasks as stated in the National Climate Program Draft System Plan: Climate Impact Assessment Tasks 1d, 1h; Climate Research Tasks 1a, 1c, 2a, 3b, 3c; Data, Information and Services Task 1.2d, 2a, and 3e.

Tomography and drifting buoy data may present problems similar to that of other remotely sensed data. The usefulness of drifting buoy data as a measure of surface current may be questionable because some buoys have been undroged. More information about data acquisition for these new types of data acquisition systems is needed. For SCUDS - more work is needed to look at the availability for interannual variations and to add new data from contemporary sources from platforms with good navigational control.

There is now a unique opportunity to collect far more accurate ship drift observations from ships which have satellite navigation facilities. Traditionally, ship drift measurements were made from ships using celestial navigation

(accurate to 50 nm?) and over 12- or 24-hour periods of drift. With modern satellite or OMEGA navigation techniques, positions can be obtained to an accuracy an order of magnitude better (hundreds or thousands of feet). Thus ship drift observations can now be made over ship drifts of only 2 or 4 hours and, with automation of the calculations, require only minimal effort by ship personnel. Therefore, ship drift observations can now be made much more accurately than previously and far more abundantly at less cost and effort than in the past. Such abundant data will allow monitoring of ocean current fluctuations on a frequent basis.

Consideration should be given to analyzed surface currents. Geostrophic current fields have been calculated from Transpac XBT data using T-S analyses from 20 degrees to 40 degrees north. These surface currents are easily accessible in the form of monthly 5-degree grids. Perhaps an even more useful data set would be Ekman current fields analyzed from geostrophic wind forcing. Such analyses have been made at the University of British Columbia. Synoptic geostrophic wind field analyses recently made for 1946-76 from the Northern Hemisphere must be used to create Ekman flow analyses which can be averaged over space and time to make a long term monthly climatology.

International/Foreign Exchange

Data required coincides with data listed under most of the other headings: surface, subsurface, sea level, fisheries, etc.

Input from other countries is vitally needed for the construction and maintenance of global ocean data sets. Perhaps most important is the need for a good inventory of foreign data sets such as that being undertaken for the GWE/FGGE YEAR by RNODC-FOY. We are not sure whether other groups feel that international exchange is critical to their needs.

Data are exchanged through mechanisms established by the IOC and WMO. Non-telecommunicated, subsurface data are exchanged using the World Data Center System. Although there has been a marked increase in the amount of data entering this system, there are often long delays, format incompatibility, and differences in the exchange medium.

For marine data, an international marine data set inventory called MEDI has been adopted by the IOC, WMO, ICES, FAO, IHO, and IAEA. Input has been slow from the centers associated with these organizations primarily because funding for operation of the system is minimal, and because the international exchange mechanism is rusty and not being utilized in its proper capacity.

Data are accessible through the WDC-A for oceanography, NCC (Surface-Marine), and NWS (Telecommunicated Data). Although data input through the WDC system is good, data forms, formats, and documentation are extremely variable. Climate program participants should support current IOC efforts to standardize exchange formats (GF-3 Format) and improve services (NODC's responsibility) and joint IOC/WMO efforts toward compatibility of data set development for the World Climate Program.

User Needs -- We cannot afford to be insular in our outlook for a National Climate Program, recognizing that oceanic and atmospheric processes do not cease to operate beyond our national boundaries. In order to adequately describe ocean-wide or global processes, data from foreign sources must be used. These seem to be particularly needed for the NCP, 5-year Plan Objectives as follows: Impact Assessment Tasks 1h, Research Tasks 3b, and 3c, and Data, Information and Services Tasks 1.2b, 2a, and 3e.

Remotely Sensed Ocean Data

Ocean data taken by remote sensors provide important information for climatic research. Remote sensors on satellites can produce data which provide global distributions of ocean-wave characteristics, sea-surface temperature, ocean currents, sea-level elevation, surface winds, and fresh water inflows. Aircraft and in situ data collection platforms can also be used to provide complementary remote data in areas where the satellites do not provide sufficient coverage.

Oceanic and atmospheric data must be combined to define the air/sea interface which is vital to the climatic research model. Therefore, secondary ocean data required (along with the Atmospheric Working Group) are: atmospheric temperature soundings, cloud distributions, surface air density, precipitation, and fluxes of salt and water across the sea-air interface.

Currently, remotely sensed infrared data exist on a near-global, synoptic basis, beginning with 1973 from a series of satellites. These data should be retained, consolidated, and archived as a common data set for time-series use.

Remotely sensed oceanographic data were taken during the period of July to October 1978 by Seasat. Due to a lack of funds only small portions of these data were processed for experimenters use. Now processing of these data into geophysical units for broad use is underway by JPL, but on a limited basis. Completed data sets are being forwarded to the Environmental Data and Information Service. Processing will not be completed until fiscal year 1980.

Future remotely sensed oceanographic data are anticipated from the National Oceanic Satellite System (NOSS) in 1984-1989. To assure the proper processing and availability of these data, special funding considerations are recommended. These data will be very important to oceanographers and should be archived in both geographic and time-series data sets.

Synoptic ocean-air interface measurements are urgently needed for climatic studies. Historical surface data are sparse in both space and time and do not yield enough information on inter-annual variability. Although the capability for remote sensing in the area of interface measurements is only developing, the pursuit of these data should be stressed and data sets from satellites should be anticipated.

Fisheries Data

Certain data on marine fisheries are considered important in order to ascertain the effects of climate on these fisheries. These fisheries data include harvest statistics (catch or landing data), survey estimates of abundance (usually research findings), production estimates (estimates of biomass), and process-oriented linkage data (from ECO systems studies).

Harvest statistics are available from the late 1800s for some species off the United States. Data from surveys of abundance are available from about 1950. Production, or biomass estimates are available for only a few species for a very few years. Process-oriented linkage data (or ECO system studies) are available for even fewer species and for fewer years.

An inventory of data sets in the above mentioned four categories is vitally needed. Harvest statistics, however, are published by the National Marine Fisheries Service routinely. In the other three categories, data are available from the various research centers of the National Marine Fisheries Service. Users of the data are cautioned that many inhomogeneities exist in these data, and thus users are advised to work closely with biologists who understand how the data were collected.

Users are not often able to obtain fisheries data in computer compatible form. Harvest data is only marginally useful without catch-per-unit effort statistics and age breakdown.

Long-time series of year class strength (abundance data) are required for major species, as well as more information on bio-environmental linkages for early life stages of major species. It is important to emphasize that climatic/fishery analyses should be conducted in conjunction with biologists familiar with bio-environmental phenomena and data, in order to avoid incorrect inferences that may be drawn otherwise. An inventory of available fisheries data, both U.S. and foreign, should be developed.

Time Series Ocean Data

This item refers specifically to coastal and nearshore, non-estuarine, physical oceanographic, surface and subsurface data as they affect fisheries assessment and atmospheric processes. Needed are a series of U.S. coastal stations with long-term (greater than 20 years) continuous sampling of temperature, salinity, currents, and water temperature. U.S. Tidal Stations can fill some of these requirements, but no other networks exist as such.

As an example, data at 30 tide stations with a period of 40 years have been collected, but for the bulk of these data only summaries are available. These data, as well as others, require digitization. A pilot program to seek out and evaluate data sets currently described in NODC's environmental data base directory will be needed, as well as procedures and programs to perform quality control of these data.

Ocean time series data may be available but are not necessarily in a form that is directly applicable to user needs.

If sufficient data exist to construct a good time series data set it would be useful to National Climate Program objectives cited in the draft preliminary 5-year plan under Climate Impact Assessment Task 1d; Research Tasks 1a; and Data, Information and Services Tasks 1.2a, 1.2b, 1.4a, 2a and 3c.

A cooperative program of NOS, NMFS, and EDIS has started to develop a tape of monthly mean sea surface temperature, surface density, and sea level (tide height) at NOS coastal tide stations in the U.S. The resulting data set should be updated and merged with foreign data. This data set will be useful in climate studies and is analogous to data tapes developed for land station data by INCAR.

Sea Level

Tides in the ocean have been monitored at many stations worldwide since before 1900. These data constitute an important climatological record as the long-term signals present in long period sea level records are affected by such climatic factors as wind, ocean currents, and global freezing and melting of ice.

Ocean current fluctuations are important in understanding heat advection from the tropics to temperate regions. Since historical records of ocean current fluctuations are almost non-existent, information on past currents could be inferred from such indirect historical records as sea level.

Very long term climatic fluctuations such as glacial-eustatic variations due to variations in the Antarctic and Greenland ice caps and other factors can also be obtained from sea level records.

Standard statistical and analytical techniques exist for removing tides and other relatively high frequency factors, and noise may be effectively reduced by low-pass fitters. Vertical tectonic movements are eliminated by adjacent station comparisons with independent geodetic verification. This leaves series (corrected for gravity) that can be meaned to provide a composite record for glacial-eustatic variations and apparent secular trends.

Also collected at many tide gages are daily sea-surface temperature, density, and air temperature observations. Long records of these data are also useful for studies of coastal climate but are subject to numerous problems due to sampling errors and non-representative location of gages in shallow water.

Tide stations in the United States are operated by the National Ocean Survey which has uninterrupted data series extending back to 1939 or earlier at 29 locations along the coasts of the United States. The oldest uninterrupted series, at San Francisco, dates from 1860.

At each tide station data, data are recorded continuously on a marigram or are recorded digitally on a punched paper tape. All processing, reductions, analyses, and archiving are performed by the Tides and Water Levels Division, Office of Oceanography, NOS. The sea level values are available in hard copy tabular form. These yearly mean sea level values (as well as monthly values) may be obtained from the Tidal Datum and Information Branch.

NODC should try to assemble foreign data in cooperation with Permanent Service for Mean Sea Level, Birkenhead, U.K.

Bathymetry

The best obtainable bathymetric data are required on a global basis and in digital form for computer modeling. Water mass movement can be influenced by sea floor configuration (e.g., submarine canyon extent and alignment, through narrow straits and ridge abruptness). Recognizing constraints imposed by time and funding, plus the fact that given geographic regions may not have coverage to the accuracies and densities required, priority processing of bathymetric data include continental shelf areas, and those exhibiting rapidly changing configurations as

well as in and about major ocean currents. Bottom roughness information may also be critical in certain situations, although specific qualitative significance to modeling goals is unknown at this time.

Basic information required from other working groups includes specification of the degree of density of coverage for geographic areas of Climate Program interest.

Generally, data are available in a 600-mile band off the eastern United States from eastern Georges Bank south to Bermuda, thence to a point east of the Florida Keys; the Gulf of Mexico; the West Coast of the United States to about 200 miles; in an irregular band of 1,000 miles from Hawaii to the Aleutian Islands; the Red Sea and the Persian Gulf; in and about Japan and southeast of Japan; and the Eastern Atlantic from Norway to Casablanca to about 200-600 miles offshore.

Data of lesser reliability and/or density are available off the east and west coasts of Mexico; about the Philippines; off China and Korea; in the mid- and south Atlantic; off Africa from Morocco to Liberia; and in the Black Sea and Mediterranean Sea.

Sparse data are found in vast expanses of the south and southeast Pacific; large portions of the Arctic and Antarctic Oceans; and in many smaller areas within the regions mentioned above. On a case by case basis, isolated areas, within those cited as having less reliable or sparse data, may contain useful data. Bottom roughness information has been analyzed in portions of the Pacific and Atlantic. Data on bottom roughness will be required in many key areas. The extent to which this parameter plays an important role in computer modeling, vis-a-vis climate, requires further elucidation by computer modeling experts.

The only large areas where bathymetric data exist in digital form are off the east and west coasts of the United States (data from about 1930). Some data are digitized off Oregon and Washington, and in selected areas of the North Pacific and North Atlantic. Considerable amounts of useful data are found in contoured form. In many cases these data sets are amenable to digitization. There is, however, no program to accomplish this.

Worldwide bathymetric data holdings are maintained by NOAA's National Geophysical and Solar-Terrestrial Data Center in Boulder, Colorado and the DOD Bathymetric Data Library in Washington, D.C. However, DOD data are partially classified and thus unavailable.

Known user needs should be ascertained with respect to bottom roughness requirements. Basic modeling criteria will be required before any significant bathymetric data accession program is undertaken.

The basic density criteria as discussed by the group seems to be on the order of one observation per 20 by 20 nautical miles as a minimum. Greater densities, however, will be required in certain critical areas.

A more definitive inventory of bathymetric data holdings should be obtained by EDIS.



NASA HQ EB79-2956 (C)
7-9-79

FIGURE 3a. The sun's radiation and the Earth atmospheric circulation.

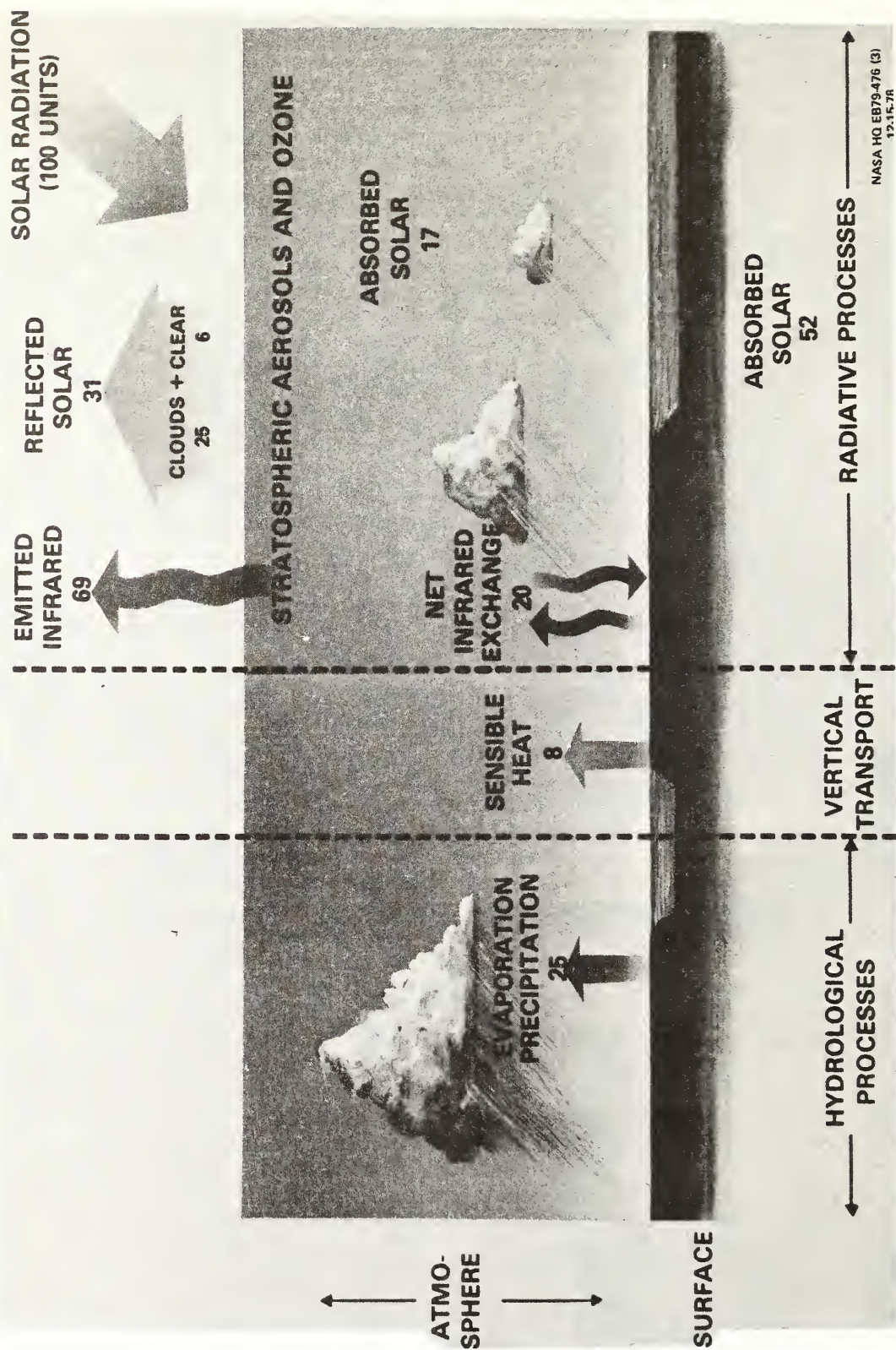


FIGURE 3b. Processes contributing to the radiation balance of the Earth/atmosphere.

RADIATION, PHYSICS, AND CHEMISTRY

Working Group 4

Co-Chairmen: Albert Arking
Otto W. Thiele

Members: Albert J. Fleig
Gary Herbert
Frederick B. House
Julius London
M. Patrick McCormick
Karen W. Posey
Frank T. Quinlan
P. Krishna Rao
Michael Riches

GENERAL RECOMMENDATIONS

1. Establish an on-going group to:
 - Maintain contact with data sources and user representatives at national and international levels
 - Review status of data in various disciplines
 - Provide guidelines for archival and dissemination of data
 - Develop climate data inventory

(Note: The completion of Roy Jenne's report to JOC should go a long way towards achieving the first two items; he should be strongly encouraged and provided all the assistance he needs.)

2. Bottom up design: it is too early to design an all-inclusive climate data system; establish inventory nuclei that are readily amenable to organized handling and expand outward from each nucleus. Examples: U.S. solar radiation data set; ozone data, sea-surface temperature data, etc.
3. Documentation (assumptions, errors, biases, supporting data, algorithms, results of intercomparisons, etc.) critical to value of any data set.
4. If practical, do not destroy original form of data unless there is assurance of no loss of information.

5. Reduced data and higher order products should be documented and archived as they are developed.
6. Bring together related data from different sources, make compatible, keep careful documentation on merging, transformations, etc.
7. Maintain close relationship between data base development and research activities.
8. The NCPO is encouraged to sponsor a series of activities to improve the interaction between producers and users of climate data. Specific tasks include:
 - Develop a comprehensive inventory of climatic data
 - Produce general guidelines for data processing, management, and archiving.
 - Provide recommendations as to areas where additional effort at collecting processing, merging, etc., are needed.
9. Organizations developing plans for experiments which may produce climate parameters are strongly urged to recognize the importance of providing useful data at every stage in the planning process.
10. Agencies sponsoring experiments from which climate parameters may be extracted are strongly encouraged to consider the plans for processing, validating, and disseminating the data in their evaluation process and to assure adequate funding for these tasks.
11. Develop a formal feedback mechanism between data managers and users with the specific goal of obtaining and disseminating new information about specific data sets. User comments and reports should become a part of the data set documentation.

SCOPE

The data categories considered within the sphere of this working group are listed in Table 1. Due to last minute changes in the working group, and the existence of nearly conflicting workshops on closely related topics, we were unable to obtain representation for category (Geo- and Biochemical) and category (Solar-Terrestrial Effects) and therefore dropped

Table 1. Radiation, Physics, and Chemistry Data Categories

<p>* 1. Radiation Components</p> <p>--Top of Atmosphere</p> <p>net radiation solar constant reflected solar emitted terrestrial</p> <p>* 2. Radiation Components</p> <p>--Surface</p> <p>solar down, up IR down, up net radiation</p> <p>3. Atmospheric Radiation</p> <p>Solar and IR (Various Levels)</p> <p>4. Air-Surface Interaction</p> <p>sensible and latent heat fluxes momentum transport (friction)</p>	<p>* 5. Clouds</p> <p>fractional cover height (top and base) optical properties macrostructure (e.g., brokenness liquid water content</p> <p>* 6. Aerosols</p> <p>tropospheric stratospheric</p> <p>* 7. Trace Gases</p> <p>CO₂, O₃, CH₄, SO₂ stratospheric H₂O</p> <p>8. Geo- and Bio-Chemical</p> <p>ocean (salinity, carbon chemistry) soil (humus) vegetation growth rates (photo- synthesis)</p> <p>9. Solar-Terrestrial Effects</p> <p>sunspots, flares sector boundaries geomagnetic activity</p>
---	---

*Areas of consideration of Working Group 4.

them from consideration. We also dropped categories 3 (Atmospheric Radiation) and 4 (Air-Surface Interaction) because of the limited availability of such data and the lack of expertise in these areas amongst the working group members. This left five areas (marked by asterisks) in which consideration was given to the status of climatic data in those areas.

In the short period of time available it was not possible to uniformly consider each of these five areas. Instead, specific examples were treated. These examples were chosen either because of their importance or because they were typical.

In addition to considering the status of climate data in specific areas, we considered issues of general concern which cut across the spectrum of disciplines. We found that many issues were common to all categories of data and therefore we appropriately highlighted these general issues.

TOWARDS MEETING WORKSHOP GOALS

Of the four goals established for the workshop, the first two--initiating development of an integrated inventory and a preliminary assessment of the status of climate data--could not be achieved by means of one workshop. To meet these goals a dedicated effort over 1 to 2 years is probably necessary. In this section we will discuss an approach for evaluation of the status of climate data, development of an inventory, and compilation of high quality data sets to meet user requirements.

ON-GOING GROUP TO EVALUATE DATA STATUS AND DEVELOP INVENTORY

There is no simple way to obtain the information necessary for evaluation of data quality, availability, and utility. The responses to questionnaires, which were sent out by each working group, are not sufficiently detailed nor is there uniformity in the standards used by the responding individuals to make the returns useful for the evaluation. On the other hand, Roy Jenne's draft of the report to the Joint Organizing Committee for GARP entitled, "The Global Data Base for Climatic Research," is an excellent start. When completed, the document will go a long way towards providing the required evaluation or the information needed to make the evaluation.

Recommendations

Roy Jenne should be strongly encouraged to complete the JOC report and provided all the assistance he needs.

Of course, one report is not sufficient. Data is a dynamic quantity, changing in time. Furthermore, we want to

develop a data inventory and influence the procedures for collecting, archiving, and disseminating data.

Establish an on-going group to:

- Maintain contact with institutions that produce data at national and international levels and with representatives of the user community to facilitate exchange of information and ideas.
- Review the status of data in various disciplines and recommend steps to improve the situation, where necessary.
- Provide guidelines for archival and dissemination of data to meet user requirements.
- Develop an inventory of climate data to guide users who need data.

This group would require a full time staff whose efforts would include: identifying potential data sources; obtaining information by direct visits and one-to-one meetings with individuals responsible for producing data and with user representatives; compiling and editing documents that make up the inventory description, including periodic newsletters.

BOTTOM-UP DESIGN IN DEVELOPING INVENTORY

A complete inventory of all climatic data is probably beyond our capability at this time. It is difficult enough to identify the spectrum data that should go into such an inventory, let alone to specify how those data are to be described, organized, and documented. On the other hand, there are a number of disciplines within climate where the data are readily amenable to archival, placement in an inventory, and ready accessibility to the user community.

Recommendation

We should establish a number of inventory nuclei and, as we gain experience with the inventory system and develop the appropriate tools for data management, we should expand outward from each nucleus to develop the inventory system on a higher and higher level of integration.

Here is where we may experiment with new technology--taking advantage of the declining cost of microprocessors and the proliferation of intelligent terminals. With a "bottom-up" design system, some inventory nuclei may be highly advanced, as the situation permits, while others may develop more slowly.

As an example, we could cite the development of a pilot system at GSFC to inventory and provide accessibility to processed data from the Nimbus-7 satellite (i.e., level 2 and higher). This will include on-line retrieval with a wide range of analysis routines provided to the user. The success of this venture can lead to the design and development of a larger, more comprehensive system.

ROLE OF RESEARCH IN DATA SET DEVELOPMENT

The Working Group felt it important to draw attention to the close symbiotic relationship that must exist to develop meaningful data sets. Not only does research provide the algorithms for extracting information from lower level data sets, but it is also important that well-handled and timely processing of data will provide researchers with the clues and information needed to optimize the observing system, develop better sensors, and improve the information extraction methods.

STATUS OF REPRESENTATIVE CLIMATIC DATA AND DATA SPECIFIC RECOMMENDATIONS

RADIATION BUDGET COMPONENTS AT THE TOP OF THE ATMOSPHERE

Radiation Budget Component observations are essential for the monitoring, diagnosis, and assessment of climate related activities and the requirements and accuracies needed for these parameters appear in various publications. (Joc. 16, Climate Plans of US, NASA, NOAA, etc.) Only satellites can provide these parameters. All the data that are currently available for climate studies at the present time were received from polar orbiting research and operational satellites, and the trend will continue into the early 1980s. The longest continuous record of measurements of these components was derived from the imaging sensors (Scanning Radiometers) on the operational polar orbiting NOAA satellites.

Before making any recommendations about the availability and quality of the radiation budget components for climate studies, some of the inadequacies in the current data should be identified. The data derived from operational satellites were received from imaging sensors whose response is confined to very narrow spectral intervals. In converting the measured radiances into spectrally integrated fluxes, assumptions were made with regard to atmospheric transmission (for the IR) and the angular distribution of the reflected solar radiation. No documentation is available with regard to these assumptions in the archived data sets. Since it is possible that the assumptions made were based on the current state of the art, it is essential to provide all the supporting documentation.

The earlier satellites did not have any on-board calibration, and the accuracies of the derived data were compared with few available surface observations. However, satellites during the late 1960s had on-board calibration facilities in the IR and they were utilized in adjusting the data. No on-board calibration is available for the VIS channels and only indirect comparisons could be made to make appropriate measurements. Documentation on these items in the radiation budget data are essential.

It should also be pointed out that the satellite measurements correspond to a particular local time/s (due to orbital geometry) and hence the measurements do not represent a true diurnal cycle. The radiation budget parameters derived from these limited samples for climate purposes need careful evaluation.

Radiation budget data sets that are available at present are derived from various satellites and different types of sensors and do not correspond to the same local time. In order to establish a continuity in the record, methods have to be devised to interpret the data to constitute a homogeneous and meaningful set.

At present the data are available in grid print forms and in mapped formats and time averaged (monthly). Consideration should be given to alternate formats for the dissemination of data and easy accessibility for the user community. Since the volume of these data are large, perhaps techniques should be developed to summarize the data in a suitable form.

Recommendations

Archival of Past Data Sets. It is recommended that Earth radiation budget data, acquired from operational and research satellites before 1979, be assembled, documented, and placed in the National Climate Archive. These include observations of reflected solar radiation, emitted terrestrial radiation with available spatial resolutions (WFOV, WFOV and scanning data), and observations of insolation, total as well as spectral wavelengths.

Basic Archival Data. It is recommended that all Earth radiation budget data (including past data) be archived in its basic form of individual measurements of radiant energy for future reference and use, that is, archived as Earth-located, calibrated radiances with satellite-Earth-Sun-geometry information appended. This will make it possible to apply current techniques of analyzing and interpreting Earth radiation budget measurements to the early data.

Data Limitations. Limitations of past, current, and future data should be documented. In particular, limitations in spatial resolution, geographical sampling, and diurnal sampling due to orbital geometry should be clearly described.

Documentation. Each data set should be carefully documented in a manner that is useful to the user community. Such documentation could include:

1. Sensor/spacecraft mission (references to other data acquired)
2. Instrument characteristics:
 - Absolute accuracy
 - Precision
 - Adjustments during processing for instrumental changes
3. Data Acquisition:
 - Geographical coverage
 - Spatial resolution
 - Periods of operation
4. Description of data:
 - Format
 - Averaging period
 - Order in which data is listed
5. Responsible person(s) that are knowledgeable about the basic data.
6. Feedback comments from other users of the data, literature references, etc.

Processing Software for User Requests. It is recommended that a variety of software packages be available for presenting observational data in user-selected formats. These pertain to the media of providing the data (tapes, listings, film, etc.) as well as the time-space portrayal of the data (grid maps, monthly means, sequential estimation of harmonic coefficients, etc.). These software options should accommodate computing power from hand calculators to the largest computers.

Integration of Related Data. It is recommended that a software capability be developed to provide user-selected combinations of related data. The integration of polar orbiting data, providing global coverage of the Earth, with geosynchronous data, emphasizing the diurnal component, would be desirable.

RADIATION BUDGET COMPONENTS AT THE SURFACE

No organized effort has been made to develop a surface radiation budget. Because of the interest in solar energy,

however, measurements of solar insolation have become important to the Department of Energy (DOE) and steps have been taken to include such measurements (at least for the continental United States) in the DOE geophysical data base for solar energy applications.

The solar radiation resource assessment program of the Department of Energy has as its goal to provide a quality geophysical data base to further the development of solar energy applications. What follows is a brief description of the methodology with which the data base is being developed, the solar radiation data currently contained in the data base, the solar radiation data being considered for inclusion, and the solar radiation data needed to complete the data set.

The Methodology

The methodology used to develop the data base constituted resolution of the following questions:

- Who are the end-users and what meteorological parameters must be available for their use?
- What data quality is required? (Here quality means accuracy, geographic distribution, precisions, frequency and formats.)
- What alternatives are there to direct measurement?
- What data are now available and can these data be developed into a quality data set?
- How do we make the data available to the user?

Through two studies and informal contacts with the solar energy community, the end-user and his data needs were defined (DOE 1979). Important to the National Climate Program is the scheme by which users were classified and the data needs then determined. The users were classified as Researcher and Forecaster (or Designer). The users classed as researchers are primarily interested in advanced solar energy applications and work at obtaining a better understanding of the physical and biological laws associated with solar climatology and solar energy systems. The forecasters use solar radiation data primarily as an input to problems of design, reliability, economics, and performance of solar systems.

This simple division has greatly eased the task of specifying the data sets required by the solar energy community. Data requirements (parameters and quality) from historical information, from current data networks, and from future data networks were more easily specified with this division in mind. Alternatives to direct measurement were then assessed.

At the same time, an inventory of available solar radiation data was funded. This included an initial National Oceanic and Atmospheric Administration effort to catalog and rehabilitate the data and to begin establishing a new data base. Continuing efforts are attempting to locate all solar radiation data and archive selected data sets (Williams et al. 1979).

Data from this data base are available both as corrected quantities (original data included for comparison) and as processed summaries through the National Climatic Center in Asheville. Specific references will follow with a discussion of the data available.

Solar Radiation Data (Surface Based Observations)

Included in the appendix are descriptions of the solar radiation data available at the National Climatic Center. Following are general statements about the quality of each of four data sets:

1. Solar Radiation data from the 38-station NOAA Solar Radiation Network

The data set consists of hourly global, normal incidence and diffuse measurements and the available ancillary meteorological parameters (temperature, cloud amount, cloud type, visibility, wind direction and speed, etc.).

These data are considered to be of high quality (+5 percent) since they are measured with carefully calibrated instruments of the same type throughout the network, have received consistent quality control throughout the period, and are all referenced to the same international standard. (Note: There is a requirement for reliable estimates of precipitable water and atmospheric turbidity for use in the validation models.)

2. Rehabilitated Solar Radiation Measurements

The basic 26-hourly (SOLMET) and 26-daily (SOLDAY) stations that appear in the rehabilitated data sets were created for resource assessment estimates and should not be used for basic climatological purposes because the procedure used removed all trends and altered the day-to-day and year-to-year variability. (Note: These are a requirement of reliable estimates of data quality before integration with other data sets.)

3. Geophysical Monitoring for Climatic Change (GMCC) Solar Radiation Data

These data are processed and quality controlled by GMCC.

4. Solar Radiation Measurement - Old Data Set

No basic quality control performed to remove basic instrument and calibrative errors. Data for different periods are referenced to different international scales. Data not recommended for use without rehabilitation.

Solar Radiation Data Needs

In the solar radiation data bases many omissions can be found. The historical data sets consist mainly of hourly or daily global radiation data. There are few measurements of direct beam, diffuse, spectral, albedo, terrestrial, or insolation on inclined surfaces. The current data set will include global and direct on approximately a 500-km grid spacing as recommended by the World Meteorological Organization (WMO). Spectral, terrestrial (infrared down and up), albedo, and other special data sets are being included from GMCC and the Solar Energy Meteorological Research and Training Sites. This dozen or so research quality data sets are sufficient for present and near future needs, but those users requiring long-term data sets of the special parameters will find the surface solar radiation data base lacking.

Recommendations

1. Examine historical U.S. solar radiation data base to determine if appropriate for use in climate research and assessment activities. Specifically, determine if rehabilitated SOLMET data base is adequate.
2. Expand the "research" quality data sets worldwide for use in:
 - ground truth for satellites (remote sensing)
 - climate change monitoring
 - climate modeling - radiation budget
 - energy research
3. Catalog worldwide data for assessment as to possible archival, reprocessing, etc.

CLOUDS

In the world's archives of meteorological data there are more bits of information pertaining to clouds than to any other meteorological parameter. That information is in the form of satellite images of the Earth in the visible and infrared portions of the spectrum. Yet we have precious little quantitative information on cloud cover fractions, cloud height, thickness, degree of brokenness, etc. Climate models are forced to rely on uncertain, meager information. In view of the strong

influence of clouds on the local radiation budget and their role in many climate feedback processes, the lack of quantitative data on clouds is probably the biggest embarrassment in our attempt to establish a climate data base.

Until about mid-1973 NOAA manually produced nephanalyses from the satellite imagery. These data are the basis for a cloud atlas for the tropics (30N to 30S) published by Sadler (1969). Average brightness data on a 40-km x 40-km grid were used by Miller and Feddes (1971) to derive cloud amounts. The only other organized cloud cover data are three-dimensional analyses produced by USAF/ETAC based upon all sources of information including satellite, aircraft, and conventional atmospheric data. In all of these cloud cover analyses the quality and accuracy are uncertain and the methods used are not documented. For that reason they are of marginal value.

The full potential of satellite imagery for providing needed parameters on cloud cover has not been explored. With the new satellite Earth imaging radiometers on TIROS N and the 4-channel AVHRR on NOAA 6, the prospects for deriving good quantitative cloud cover data have been substantially improved.

A computer-oriented, semi-automatic method for deriving cloud fractions from satellite imagery, using a "man-in-the-loop" to help the computer decide what constitutes a cloud, has already been successfully applied in a pilot study (Arking, 1964). Also, the infrared brightness measurements provide information on cloud heights. Using the visible and infrared brightness in a bivariate analysis, it may be possible to determine cloud type and estimate height, in addition to cloud fraction.

Recommendation

A concerted effort should be made to extract quantitative information on cloud cover from current and past satellite imagery. Due to limitations on sampling (once or twice every day) the data will not be of much value for averaging periods less than 1 month, but that is already of value of climate modeling purposes and for many analyses of climatic trends. Because of a diurnal bias (sampling at the same local times every day) it will be necessary to make a diurnal correction, but for this purpose the geosynchronous satellite imagery should be useful. Specifically, a task should be undertaken immediately to develop a systematic cloud atlas (digital and map format) containing cloud amount and cloud top height beginning with NOAA/SR data in late 1972 and continuing with current Tiros-N/AVHRR data utilizing GOES/VISSR data to fill gaps. A more exhaustive investigation would be necessary to make a

meaningful judgement on the cost effectiveness and technical feasibility of attempting to extract cloud amount from earlier satellite imagery dating back to the early 1960s. Cloud top height cannot be obtained from these earlier observations.

AEROSOLS

Climate Data Requirements

Atmospheric particles (aerosols) can affect climate through their influence on the amount of sunlight absorbed and scattered by the Earth atmosphere system and on the amount of thermal radiation emitted to space. Both natural and man-made factors lead to changes in the aerosol population and their properties and thereby potentially induce climatic alterations. Preliminary results from a variety of regional experimental programs, as well as numerical experiments of different types of non-cloud aerosols and on simple aerosol/cloud models, show significant effects. (JOC, 1978)

The description of aerosols in a concise way, amenable to their efficient use in a variety of problems, is particularly complex. This is due to the nature of the aerosol and to the variety of atmospheric processes into which it enters. Aerosols are introduced into the atmosphere from sources varying in size from local to regional. The sources may be at the Earth's surface, (e.g., volcanoes, sea spray, soil dust), or in the atmosphere itself (e.g., gas-to-particle conversion, and various airborne emissions.) Aerosol transport and lifetime in the atmosphere depend on its size distribution, altitude of injection or formation, and on synoptic weather processes. Their sink mechanisms can be both chemical and physical.

Efficient modeling of the effect of different types of aerosol on climate requires a self-consistent collection of data on the spatial and temporal distribution of their optical depth $S(\lambda)$, albedo for single scattering $W(\lambda)$, and phase function $P(\lambda)$ (or an anisotropy factor $g(\lambda)$ at different wave lengths in the solar as well as infrared region of the spectrum). To complete this climatology, their size distribution and size-segregated composition and refractive index should be included. Use of these data, especially for sensitivity tests, necessitates the bounding of their natural variability and should be included for completeness.

Status of Available Aerosol Climate Data

There has been very little data routinely archived on the general properties of atmospheric aerosols. Most data have appeared only in journals and reports and are usually obtained as a single parameter, e.g., lidar back-scattering profile, total optical depth, size distribution, etc. These

data clearly do not fulfill the needs for the proper assessment of the effects of aerosols on climate.

The only routinely archived data at present that relate to aerosol properties are the WMO global turbidity data consisting of 67 stations in 20 countries. The NCC has these data on tape from 1971 through approximately 1977. Relating these data, however, to the necessary aerosol radiative properties is not straightforward.

A number of reviews of available aerosol data are given in the recent literature (Cadle and Grams 1975, Harris 1976, Selby et al. 1976, NASA 1976). The first routine archival of aerosol data sets as called out above will be made in 1979 by two NASA spacecraft containing aerosol sensors: the Stratospheric Aerosol Measurement II (SAM II) aboard Nimbus-7; and, the Stratospheric Aerosol and Gas Experiment (SAGE) aboard the Applications Explorer Mission B. These sensors will provide profiles of stratospheric aerosol optical depth or extinction coefficient with 1 km vertical resolution. Their associated "ground truth" or correlative measurement programs (NASA 1978, NASA 1979) will provide a number of intensive field measurements of a number of the aerosol radiative properties simultaneously. The satellite data with their correlative measurements will be archived at the National Space Science Data Center, starting in the summer of 1979. Another experiment that will provide data in the very near future on stratospheric aerosol radiative properties is being organized by NASA to measure in situ aerosol properties with a number of instruments aboard the U-2 (NASA 1979).

Attempts are currently being made to interpret LANDSAT data in terms of tropospheric total optical depth and mixing layer height over regional areas. Also, coordinated multi-instrument tropospheric aerosol/radiation experiments, similar to the one performed in the southwestern United States in 1974 (DeLuisi et al. 1976), are planned. These kinds of data will be useful for determining desert-type and urban-type aerosol radiative properties and, therefore, can be used in various sensitivity studies. These studies will help determine the measurement and sampling requirements.

Future satellite instruments include the advanced version of SAGE (SAGE II) to be flown with an Earth radiation budget instrument in the ERBE program which will delineate a stratospheric optical model for determining size distribution in addition to optical depth or extinction coefficient, along with simultaneous ozone and NO₂ profiles and a lidar system proposed for the space shuttle to determine aerosol back-scattering profiles in the stratosphere and troposphere.

Recommendations

In general, an inventory of aerosol data of known quality on specific radiative and microphysical properties is needed. This inventory should be available to the climate/science community in a readily accessible form. The inventory should be similar to a library card catalogue in that the location of various data sets are made known. With these data should be a definition of their uncertainties with the instruments' operational virtues and limitations.

In order to more fruitfully use and evaluate historical data sets, it is recommended that intercomparisons be made of various instruments and methods of measurement and that complete sets of measurements be made which will provide the necessary inputs for modeling aerosol effects. These should be carried out in the same atmospheric volume as simultaneously as is possible. This will not only validate methods, but will provide as credible a data set as is possible with maximum usefulness to the science community. The combined set of data from historical sources and special programs should then be useful in modeling climatic variability.

These should be archived as they become available (e.g., SAM II and SAGE) and should include the needed aerosol properties as discussed earlier: $S(\lambda)$, $W(\lambda)$, $P(\lambda)$, (or $g(\lambda)$), size distributions, size segregated composition and refractive index, and surface albedo--all of these as a function of space and time.

TRACE GASES

Besides cloudiness, which is a first order influence on the radiation processes in the atmosphere, there are a number of radiatively active minor constituents. The primary ones are water vapor, CO_2 , O_3 and aerosols. A persistent trend in these constituents could affect climate in a significant way. Their effect on the radiation field results in changes in temperature at various levels if not balanced by dynamic or thermo-dynamic processes. Their spatial and temporal variation should, therefore, be monitored in order to understand their effects on climate.

Atmospheric Carbon Dioxide

Background

As an absorber of infrared radiation, atmospheric CO_2 directly influences the Earth's heat budget. The large increases in the level of atmospheric CO_2 , thought to be related mainly to increased use of fossil fuels and to a lesser extent to

changes in agricultural practices in the tropics, is viewed by most meteorologists as capable of causing climate change. The magnitude and kind of change anticipated cannot be determined from present knowledge, because the sources of carbon are not clearly understood and thus the concentration of CO₂ cannot be predicted with sufficient accuracy. A global scale monitoring program is required to determine the spatial and temporal variations more accurately.

Present Status of Monitoring Programs

Since 1956 atmospheric CO₂ sampling has been conducted at the Mauna Loa Observatory in Hawaii (Pales and Keeling 1965). A year later a similar program was begun at the South Pole as part of the International Geophysical Year (IGY). In 1972, a measurement program at Barrow, Alaska, was begun by NOAA (Miller 1973) with a second program at American Samoa, in 1975 (Watkins 1976). The Australian Government began a monitoring program the same year in Tasmania (Base Line 1976). At these five stations continuous measurements are presently being made in accordance with WMO recommendations (WMO 1974).

To monitor seasonal and regional variations of background CO₂ additional stations are required. CO₂ flask samples are currently being taken on a weekly schedule at Alert, NWT, and at Ocean Station "P" by the Canadian Government. In addition to flask samples at the aforementioned baseline stations, NOAA has proposed a network of 20 additional stations. NOAA has implemented the following stations at this time: Cold Bay, Alaska; Point Six Mountain, Mont.; Viwot Ridge, Colo.; Key Biscayne, Fla.; Cape Kumukahi, Hawaii; territories of Guam and Virgin Islands; and at Palmer Station in Antarctica. With the assistance of the respective governments, sampling programs have recently been started at San Cristobal, Ecuador; Huancayo, Peru; Amsterdam Island, France; and Ascension Island, UK. All flask samples from the NOAA network are analyzed on a single infrared analyzer at NOAA in Boulder, Colo. (Watkins 1976). This standardizes absolute CO₂ concentrations for this group of stations. The samples taken before 1977 have been analyzed and the results are published for the WMO by NCC (NOAA 1977).

Recommendations

With respect to atmospheric carbon dioxide it is recommended that all countries making observations submit all values to the National Climatic Center for archiving and distribution. A complete description of the analysis procedures is also necessary. If possible, the data should be made available within two years of the time it was taken.

OZONE (GROUND-BASED MEASUREMENTS)

The Climate Data Set - Ozone

Atmospheric ozone measurements - past, present, and those planned for the future - supply three different types of information serving individual needs but with mutually interacting purposes.

The measurements are for:

- Surface concentrations
- Total column amounts
- Free air concentrations - in the troposphere, stratosphere, and mesosphere

For each of these three areas of information (i.e., surface, total, and free air ozone amounts) there are many techniques of observations with, generally, different quality of the data. Therefore, the data sets need to be archived separately.

All ozone data are required for documentation of climate budget studies including analysis of statistical characteristics--both spatial and temporal. The climate studies involve the distribution and variability of ozone as an atmospheric constituent and its involvement in atmospheric radiative, chemical, and transport processes. In addition, surface ozone information is needed for studies of air pollution in both urban and suburban environments.

Experience has suggested an effective procedure for partitioning archiving responsibilities for different geophysical parameters among the various national and international organizations on the basis of specific interest, accessibility of the data, and data management expertise. This has proven to be a comfortable mode of operation of ozone data. For instance, surface data ground based total ozone measurements and the vertical ozone distributions as determined both by umkehr and balloon borne ozone sondes are collected, processed for routine, quality control and published bimonthly by the World Data Center (Downsview, Ontario). Satellite derived data are collected and archived by the National Space Science Data Center at Goddard Space Flight Center. The mode of primary data acquisition and presentation is discussed below. When ozone observations are reported in a manner that precludes evaluation or even estimates of the errors involved, the data generally lose much of their value as climatic information.

Surface Ozone

Some observations of surface ozone have been made from time to time and from place to place for over 100 years. These

data do not represent a homogeneous set and there is very little documentation on their accuracy. Literature reference to the existence of such information could be useful to interested researchers.

At present, surface ozone measurements are made, generally continuously throughout the day at a few stations throughout the world. These data are collected and processed, and mean daily (or monthly?) concentrations are routinely published by the World Data Center in Ontario. Hourly values of the surface ozone concentration are important for understanding the diurnal variation of the complex chemical processes in the turbulent planetary boundary layer and need to be archived for each observing station.

Total Ozone

Ground Based Observations

Total ozone data have been derived from various ground based observations of solar visible and ultraviolet radiation since about 1908. These data, however, are of questionable quality. The present global ozone observing system dates back to 1925 when the Dobson instrument was first put into use. From 1926 to about 1950 there were only 3 to 6 "Dobson" stations taking almost daily total ozone measurements. These observations have not been validated or, except in the single case of the Arosa series, been reprocessed as a single homogeneous set. From 1950 to 1957 the number of Dobson observing stations increased to approximately 50 and after the start of the IGY the number of stations observing total ozone, both Dobson and M-83 measurements, increased to almost 100 in the years 1965-67. Information is published bimonthly by the World Ozone Data Center giving the daily values of observed total ozone, in milli-atm cm, and includes type of observing instrument used and observing conditions relevant to the observation. The data are checked for quality control of the report but not of the observations themselves. These data represent the base climate set for total ozone observations because of their relatively long history and as validation data for present and future satellite observations.

Vertical Distribution

Observations of the vertical ozone distributions are made routinely by:

- Ground based umkehr technique
- Balloon borne electro-chemical ozone sonde
- Rocket borne optical ozone sonde
- Satellite observation by various techniques
(not discussed here)

In addition, a number of observational methods are used for occasional observations but none covers a long period of routine measurements (i.e., ground based microwave; aircraft - optical and electro-chemical, balloon borne optical, rocket borne chemiluminescent, etc.). Because of the different methods of observations, evaluations of the errors involved, and the different time and space scales of the observations, these latter measurements are difficult to archive.

Umkehr Observations

At present there are about 15 stations taking routine umkehr observations, about half of which have records for over 20 years. Observations normally are taken every day when atmospheric conditions (weather and solar elevation) are appropriate. The data are reported as the mean ozone partial pressure in each of nine standard layers (each approximately 4.5 km thick) up to about 50 km. These are included in the archived set distributed by the World Ozone Data Center.

Balloon Borne Ozone Sonde

Some chemiluminescent ozone sondes were flown at 11 stations over North America in a program supervised by the Air Force Cambridge Research Center during the period 1962-64. The data for these ascents have been published as a set of technical reports by AFCRL. Additional flights were made at some stations up to 1969. These data were collected by the Air Weather Service and are available in tape form. It must be noted that the data are not of universally good quality and this balloon borne observing technique has been discontinued.

The present network of balloon borne ozone soundings is based on an electrochemical technique. Measurements are currently being made at about 20 stations. Most stations take about 2 to 4 observations per month. The data giving simultaneous observation of ozone partial pressure, temperature, and when available, wind speed, for significant and standard levels for each station observation are published bimonthly and distributed by the World Ozone Data Center. Four stations are presently taking observations in Canada but only one (Wallops Island) in the United States. It is strongly recommended that an additional three stations be set up to take balloon borne ozone sonde observations in the United States with a frequency of three per week.

Rocket Observations

The results of many individual rocket observations are reported in the literature. These have not yet been generally archived although a number of review papers present

the results of some of the observations. The summarized data are generally in the form of molecular ozone concentration (or sometimes mixing ratio) as a function of height.

Routine optical rocket ozone sonde observations are taken at three stations in North America (one per month) and these data are made available by NASA (Wallops Island) in the form of tables of ozone concentration as a function of height for each observation.

GENERAL ISSUES IN DATA SET DEVELOPMENT AND DATA MANAGEMENT

A number of issues regarding the development of climate data sets and the services required to manage them were discussed at length by the Working Group. These issues are listed below, together with associated recommendations where a consensus was obtained from the Working Group membership. However, the NCPO is encouraged to provide for further consideration of these questions by appropriate groups. A possible approach is described in the preceding paragraph entitled "Towards Meeting Workshop Goals" above.

ISSUE 1

What criteria must be met by a data set for it to be included in a climate data base? Possible criteria include:

- frequency of observations
- time and geographic area covered
- documentation
- accuracy
- cross calibration and validation
- processing consistency
- level of data reduction
- availability of support data

Recommendation

For purposes of generating inventories of national and international holdings, all climate-related data should be included regardless of limitations in the data set in the areas listed above. However, climate data inventories should categorize data sets (e.g., as major data sets, minor data sets, etc.) based on their extent of coverage, validation, documentation, and so forth, and should include a description of the data set with respect to each of the above criteria.

Should the archiving organization:

- perform quality checks on the data?
- correct the data?
- delete data, flag data, or send it back for regeneration?
- manipulate data to make them consistent (e.g., LIMS and SBUV ozone data?)
- require standard formats for incoming data?
- reformat incoming data prior to archiving or distribution?
- require feedback from users about data set problems?

Recommendation

Data managers and archivers cannot properly operate in a vacuum. They must work closely with both the data producers and data users to gain a full understanding of the characteristics of their data holdings and requirements for user access to these data.

The data producer should assume primary responsibility for quality control (QC). However, the archiver should understand these QC procedures and should perform gross checks on all incoming data.

The extent to which the archiver should correct incoming data depends on the type of error (e.g., gross data inconsistency vs. general retrieval algorithm limitations.) At a minimum, the archiver should be aware of and maintain complete documentation of the limitations/inaccuracies inherent in each data set.

Multi-source data sets for the same climate parameter should, in general, be retained and archived as separate data sets. Where requirements dictate, such data sets may also be physically merged and massaged into a single consistent data set. In such cases, the individual source data should not be destroyed.

In most cases, producing a single unified data set from multiple sources (e.g., a best ozone data set from balloons, rockets, VUB, LRIR, SBUVITOMS, LIMS M-83, Dobson, etc.) is a very complex undertaking. It should be treated as a research task to be undertaken by a group with substantial understanding of the parameters and the data sources involved. Archive centers are warned against assuming that a simple analysis procedure can be applied in most cases.

The archiver should work closely with the data producers to develop data set standards (format, error handling, documentation, and so forth) and should strongly encourage data producers to conform to these standards. When standards are not met, data reformatting by the archiver prior to distribution to the user is encouraged.

ISSUE 3

What services should be provided in the following areas?

- data extraction and sorting
- statistics, contours
- analysis to standard grids
- correlations among data
- averaging by time or space

Recommendation

To the extent practical, these services should be provided for the user community. In general, standard products should be defined and generated by the data producers and routinely maintained by the archivers. In addition, archivers should be responsive to user requests for custom-tailored products requiring data reformatting, regridding, and similar manipulations where practical and cost effective. The panel noted that requiring reimbursement of (some or all of) the archiving center's costs may be desirable to reduce spurious requests.

ISSUE 4

What closed loops are needed by the archiving organization in terms of:

- maintaining a record of users requesting and receiving data? (see next item)
- notifying users when errors are detected in the archives or data sets are updated?
- recording and disseminating research results based on the data?
- receiving feedback from the users on the usefulness of or problems with the data?

Recommendation

The archiver and data producer should assume joint responsibility for keeping the user community aware of the current status and integrity of disseminated data sets. Feedback from users to archivers and producers should be established for providing information on the usefulness of and problems with

disseminated data. The archiver is encouraged to maintain bibliographic information on pertinent publications and research reports relating to his data holdings.

ISSUE 5

What are the time requirements on data and information access and distribution?

- on-line vs. off-line requirements
- real-time vs. delayed
- electronic vs. manual distribution

Recommendation

The Working Group felt that time requirements on data and information access and distribution vary widely for different data sets and user categories. However, the following general guidelines are recommended:

- Data producers should be encouraged to make their data publicly available as soon after acquisition as practical rather than waiting for the "perfect" data set to be produced. The quality and status of these interim data sets should be fully documented and such qualifications should be provided with the data.
- In general, rapid bulk electronic transfer of large volumes of data is not envisioned as a frequent requirement. However, archivers should be encouraged to provide rapid and easy access to information describing their data holdings and to low volume data sets (e.g., statistical summaries and sample views of large data sets.)

ISSUE 6

What information should be included in climate data catalogs?

Recommendation

Climate data catalogs should contain sufficient information about each archived data set to allow the user to correctly evaluate the applicability of the data set to meet his requirements prior to ordering or requesting bulk transfer

of the data set. While specific information will be data-set dependent, the following types of information should be included:

- investigator's purpose/intent in collecting the data set
- precise description of the measured or derived parameters included in the data set
- spatial and temporal coverage, resolution, and frequency of the data values
- data set volume
- validation methods applied to the data set; validation results
- consistency with other sources
- data set statistics or similar summary information
- the name and affiliation of the individual responsible for the data set content
- bibliography of related documentation
- cost of ordering the data

REFERENCES

- Arking, A., 1964: Latitudinal distribution of cloud cover from Tiros III photographs, *Science* 143, 569-572.
- Base Line, 1976, 1978: Baseline air monitoring report, 1976, Australian Government Publishing service, Canberra.
- Cadle, R.D., and Grams, G.W., 1975: Stratospheric aerosol particles and their optical properties, *Reviews of Geophysics and Space Physics*, 13, 475-501, 1975.
- DeLuisi, J.J.; Furukawa, P.M.; Gillette, D.A.; Schuster, B.G.; Carlson, R.J.; Porch, W.M.; Fegley, R.W.; Herman, B.M.; Rabinoff, R.A.; Twitty, J.T.; and Weinman, J.A., 1976: Results of a comprehensive atmospheric aerosol-radiation experiment in the southwestern United States. *J. Appl. Meteor.* 15, 4410463.
- U.S. Department of Energy, 1979: Insolation resource assessment program plan, DOE/ET-0082.
- GMESAC, 1975, 1977: Global monitoring of the environment for selected atmospheric constituents, 1975, NOAA/EDIS/NCC Asheville, Sept. 1977.
- Harris, F.S., 1976: Atmospheric Aerosols: A literature summary of their physical characteristics and chemical composition. NASA CR 2626, January 1976.
- JOC, 1978: Report of the Meeting of the JOC Working Group on Aerosols and Climate, Boulder, Colorado, August 7-11, 1978. Available from ICSU/WMO, Geneva.
- Miller, D.B., and Feddes, R.G., 1971: Global atlas of relative cloud cover, 1967-70, based upon photographic signals from the meteorological satellites. U.S. Dept. of Commerce and U.S. Air Force, Washington, D.C.
- Miller, J.M. (ed), 1973: Geophysical monitoring for climatic change no. 1, Summary Report 1973, U.S. Dept. of Commerce, NOAA, 79 pp.
- NASA CP 2004, 1976: Atmospheric aerosols: Their optical properties and effects.
- NASA TM 78554, 1979: Guidelines for the aerosol climatic effect special study, February 1979.
- NASA TM 78747, 1978: SAM II Ground Truth Plan, June, 1978 - Available from NTIS, Springfield, Va., P. B. Russell, M. P. McCormick, L. T. McMaster, T. J. Pepin, W. P. Chu, and T. J. Swissler.

- NASA TM 80076, 1979: SAGE Ground Truth Plan, March 1979,
Available from NTIS Springfield, Va., Edited by P. B. Russell.
- Pales, J., and Keeling, C.D., 1965: The concentration of
atmospheric CO₂ in Hawaii, J. Geoph. Res 70, pp. 6053.
- Sadler, J.C., 1969: Average cloudiness in the tropics from
satellite observations. East-West Center Press, Honolulu.
- Selby, J.E.A., Shuttle, E.P., McClatclay, R.A., 1976: Atmospheric
transmittance from 0.25 to 28.5 m. Supplement LOWTRAN 3B
(1976), AFGL-TR-0258 Environmental Research Papers No. 587,
Air Force Geophysics Laboratory, Hanscom AFB, Mass.
- Watkins, J.A. (ed), 1976: Geophysical monitoring for climatic
change no. 4, Summary Report 1975, pp. 131.
- Williams, B.B., Cristina, J.R., and Carter, E.A., 1979: Solar
Radiation Observation Stations, updated to 1979, U.S. DOE,
ORO/0175-1.
- World Meteorological Organization (WMO), 1975: WMO Operations
manual for sampling and analysis techniques for chemical
constituents in the air and precipitation. WMO-No. 299,
World Meteorological Organization Geneva, Switzerland,
ISBN 92-63-10299-6 pp. 56.

APPENDIX

DESCRIPTIONS OF FOUR SOLAR RADIATION DATA SETS AVAILABLE AT THE NATIONAL CLIMATIC CENTER

SET #1

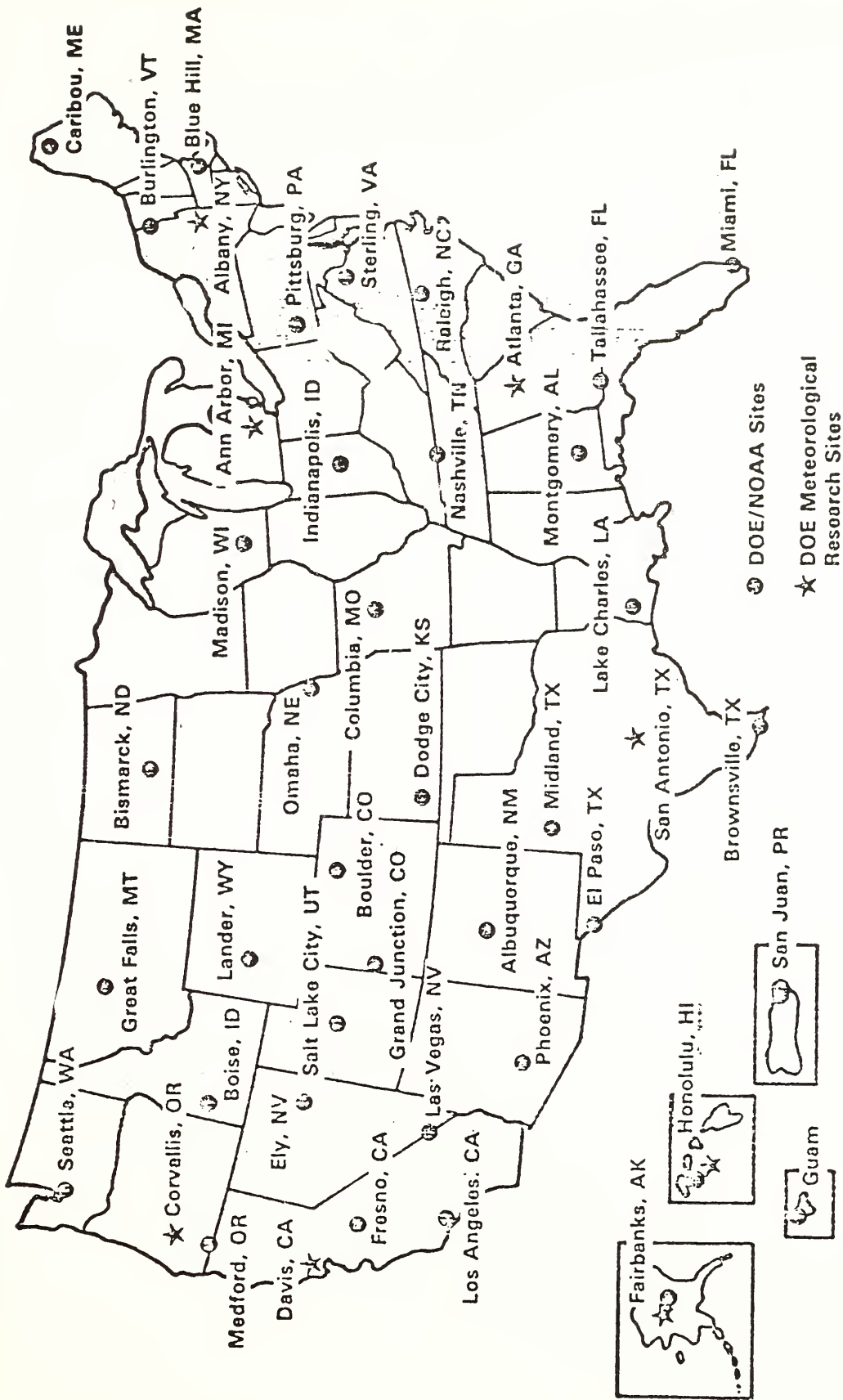
Title: Solar Radiation Data from the 38-Station NOAA Solar Radiation Network

Description:

1. Type of Data = Global, diffuse, and normal incidence solar radiation are measured at 38 locations. Spectrolab and Eppley pyranometers are used for global and diffuse radiation measurements. Eppley pyrhemometers are used for normal incidence radiation measurements.
2. When = Global radiation measurements began in January 1977, diffuse radiation measurements in July 1977, and normal incidence measurements in January 1978. All stations measure global and normal incidence radiation. Only ten measure diffuse. Data are integrated hourly in local standard time.
3. Space Coverage and Resolution = Data are measured at 34 National Oceanic and Atmospheric Administration (mostly National Weather Service) sites in the contiguous United States as well as at Fairbanks, Guam, Honolulu, and San Juan.
4. Data Characteristics, Status, Quality = All sensors are calibrated annually at the Air Resources Laboratories' Solar Radiation Facility in Boulder, Colorado. Data are recorded on cassettes as one-minute integrals. The cassette data are later integrated hourly in local standard time. This constitutes the "observed" data file. The observed data file is copied to create an "edited" data file. The edited data are rescaled (calibration input) and nighttime biases are removed. The global data are then compared with a clear sky model and displayed as time series on a color graphics CRT. Flags are assigned to values which exceed prescribed deviations from the model or are deemed questionable in the light of concurrent meteorological data. Diffuse and normal incidence radiation data are subjectively reviewed as they relate to the global measurements and atmospheric conditions.

5. Relationships Between Data Sets = The data set contains both the original (hourly integrated) data as well as edited data. At the present time, the set includes no derived data, though modeled or estimated values will be added in the future to fill gaps.
6. Data Organization = Data are available in a format similar to SOLMET, one month, all stations per magnetic tape. The logical records are ordered chronologically within station number in ascending order.
7. Media = Radiation data are published monthly in Monthly Summary, Solar Radiation Data, a publication of the National Climatic Center. They are also available with collateral meteorological data on 9-track magnetic tape. As of April 1979, there was a 22-month backlog of partially processed data.
8. Volume = Magnetic tapes contain one-month's data for all operational stations, one 163 character logical record per hour, 24 hours per day.

For more information address the Director, National Climatic Center, Federal Building, Asheville, N.C. 28801 or call (704) 258-2850, ext. 683.



DOE/NOAA 38 Solar Radiation Monitoring Network and DOE 8 Solar Energy Meteorological Research and Training Sites.

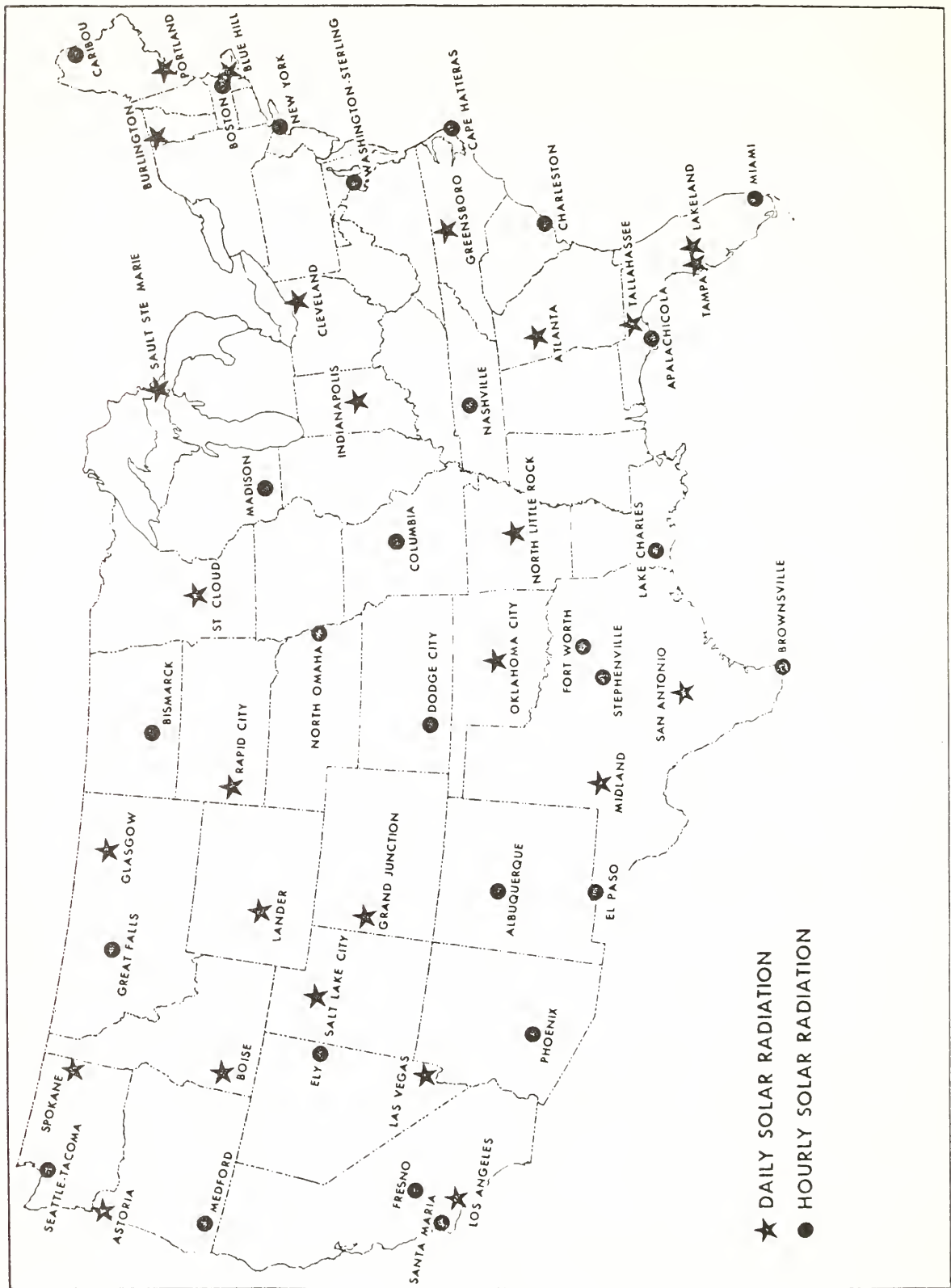
Title: Rehabilitated Solar Radiation Data

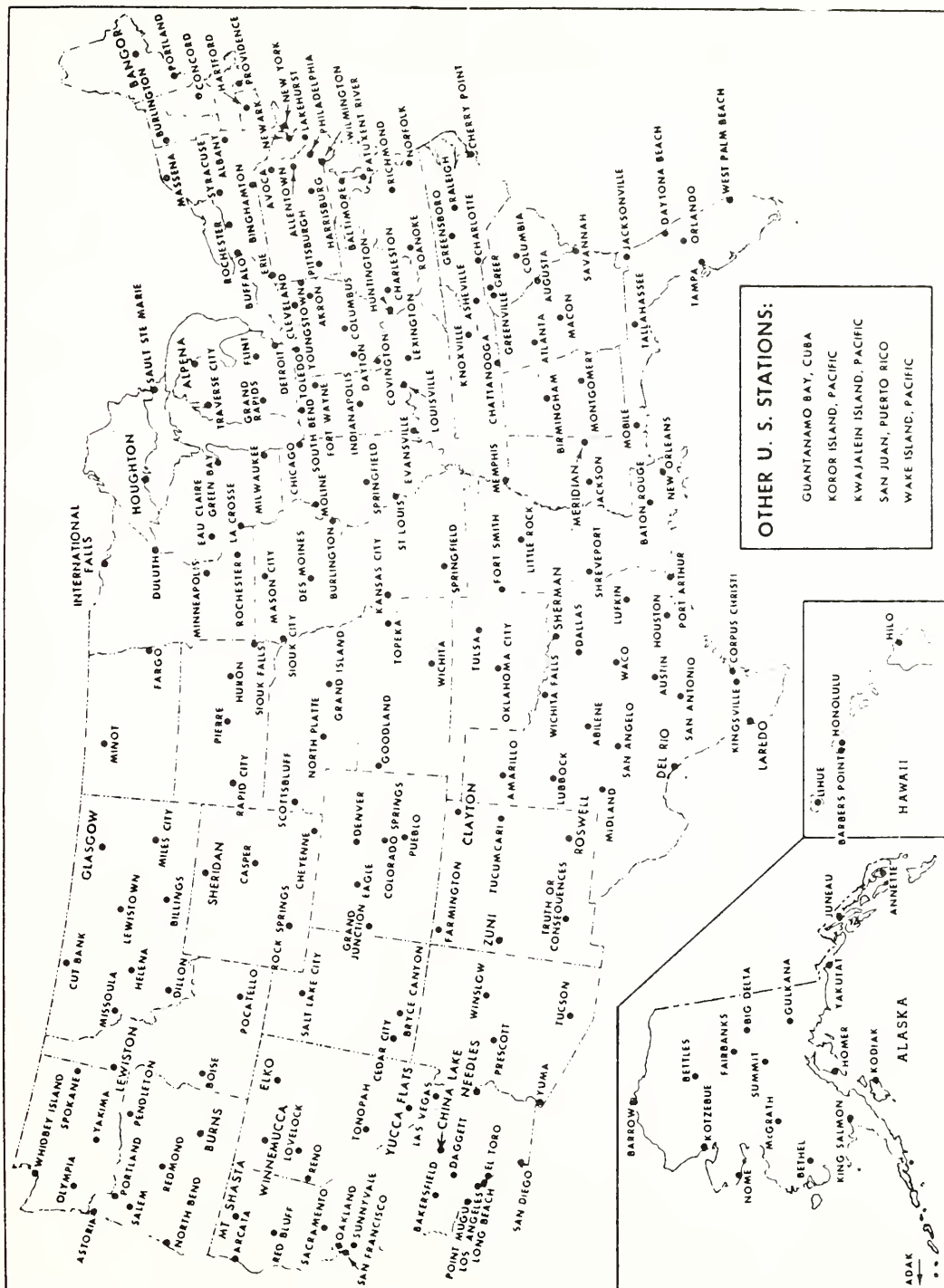
- TD 9724 - SOLMET Data
 - TD 9723 - SYI/Direct SOLMET Data
 - TD 9734 - Typical Meteorological Year Data
 - TD 9744 - Input Data for Solar Systems
 - TD 9739 - SOLDAY Data
-
1. Type of Data = Observed global insolation data measured by Eppley pyranometers. Data are observations and derived statistics (sums, means, etc.)
 2. When = Hourly and daily time resolution generally for the 1952-1976 period.
 3. Coverage = United States - 26 hourly observed data stations, 222 hourly derived data stations, 26 daily observed data stations.
 4. Data Characteristics = Quality control comparisons were made with extraterrestrial radiation values and cloud/sunshine models. Data accuracy goal was plus or minus 5%. Non-temperature corrected clear solar noon values introduce a maximum 14% possible error in northern stations in winter.
 5. Relationship = The SOLMET and SOLDAY data sets contain observed, edited and modeled global insolation, as well as collateral meteorological data. SOLMET also contains modeled normal incidence radiation data. SOLMET gives hourly resolution data, whereas SOLDAY gives daily resolution. Input data for Solar Systems contain mean daily global solar radiation from SOLMET by month as well as mean daily maximum and minimum temperatures and monthly heating and cooling degree days. The Typical Meteorological Year Data Set contains hourly radiation data selected from SOLMET to represent a "typical" year. The SYI/Direct SOLMET Data Set contains only edited or modeled global radiation data as well as derived normal incidence data.
 6. Data Organization = Data on magnetic tape are arranged chronologically within station, in ascending order.
 7. Media = Magnetic tapes. The Input Data for Solar Systems Set includes printed tables (see reference).

8. Volume = Magnetic tapes as follows:

SOLMET Data	248 nine-track tapes
SYI/Direct SOLMET Data	2 nine-track tapes
Typical Meteorological Year Data	26 nine-track tapes
Input Data for Solar Systems	1 nine-track tape
SOLDAY Data	1 nine-track tape

For more information address the Director, National Climatic Center, Federal Building, Asheville, N.C. 28801 or call (704) 258-2850, ext. 683.





REGRESSION MODELED SOLAR RADIATION DATA STATIONS

Title: Geophysical Monitoring for Climatic Change (GMCC)
Solar Radiation Data

Description:

1. Type of Data = Global and normal incidence pyrliometer observations through quartz domes or windows and colored filters GG22, OGI, RG2, RCB and UV.
2. When = Data were taken from January 1976 through June 1978. Global radiation data are given in two-minute integrals. Normal incidence data are discontinuous and are taken during clear sky conditions.
3. Space Coverage and Resolution = Data are taken at Mauna Loa Observatory, Hawaii; Barrow Observatory, Alaska; Amundsen-Scott Station, South Pole; and Samoa Observatory, Pago Pago, American Samoa.
4. Data Characteristics, Status, Quality = Instrument calibrations have shown that the OGI and RGB hemispheric domes direct solar beam transmission may change with time of day and also with different solar elevation from season to season. Inhomogeneity in the domes is the cause of the changes. The magnitude of the changes are on the order of + or 1 percent with a maximum of + or 5 percent. Data analysis should take this into account. The absolute values for the data from the UV pyranometer are provisional. Obstructions from towers prevent continuous unobstructed measurements of irradiances at the South Pole over a 24-hour period. An intermittent grounding problem caused noise in the global radiation data during 18 days in October and November 1976 at Mauna Loa. Mauna Loa's GG22 pyranometer was periodically shaded by a tracking disk to obtain diffuse radiation measurements during 1976. Filter factors (about 1.10) were applied to normal incidence data from the four locations.
5. Relationships Between Data Sets = The original data are assembled at the National Oceanic and Atmospheric Administration's Environmental Research Laboratories in Boulder, Colorado.
6. Data Organization = Global and normal incidence data are on separate tapes. Data are arranged in chronological order. Each logical record contains measurements from up to five sensors/filters. A tape may contain more than one file.

7. Media = Data are on 9-track magnetic tape.
8. Volume = The current data set (as of 4/19/79) resides on ten magnetic tapes. South Pole 1976 and 1977 global data are on one tape. The 1977 normal incidence data for all four stations are on one tape. Otherwise, tapes contain one station-year of data. Global data are available for 1976, 1977, and January-June 1978 at Barrow and Samoa and for 1976 and 1977 at Mauna Loa and the South Pole. Normal incidence data are available for 1977 only.

For information on tape copies, write to the Director, National Climatic Center, Federal Building, Asheville, N.C. 28801 or call (704) 258-2850, ext. 203.

For information about the data collection or processing, write to Bernard Mendonca, NOAA-ERL Air Resources Labs. (R329), Boulder, Colorado 80303 or call (303) 499-1000, ext. 6811.

SET #4

Title: Solar Radiation Measurement (Old Data Set)

Description:

1. Type of Data = Measurements are on file for hemispheric (global) solar radiation data as hourly and/or daily, normal incidence, net exchange and ultraviolet. The hemispheric sensors in use were Eppley pyranometers (CSGI 1958). The normal incidence (NIP) instruments were Eppley pyrhemometers. The instruments responded to a wavelength of 0.3 to 3 microns. Net exchange (net) and ultraviolet (UV) networks were small and consisted of private equipment.
2. Where = Solar radiation records began in the U.S. in March 1903. The bulk of the data began in July 1952 and continued through December 1976, when the old type data set ended.
3. Space Coverage and Resolution = From a one-station operation in 1903 the network expanded as follows: 1920s, 5 stations; 1930s, and 40s, 24 stations; 1950s, 83 stations; and 1960s and 70s a maximum of 90 stations. Stations were well grouped over the contiguous states, with a few overseas locations.
4. Data Characteristics, Status, Quality = Only gross quality control was done for continuity on the hemispheric data. These data were also checked against computed extraterrestrial radiation values. No quality control was done on NIP, UV, or net exchange data. Data accuracy was probably not greater than 14 percent. Hemispheric pyrometers were subject to color change and moisture, and were uncompensated for temperature change. Changes in other equipment are unknown.
5. Relationships Between Data Sets = The data came from National Weather Service (NWS) stations and private cooperators. The data were received as paper manuscript or punch cards as well as original strip or circular (NWS only) charts. Hemispheric data were key punched, edited and placed on magnetic tape. For the area involved the size of the data set is minimal.
6. & Data Organization and Media = Data are available as paper copy of original charts or observer tabulations, as computer printouts, or as copies of magnetic tapes. Manuscript records are filed by subject and name. The magnetic tapes are in a five group number identifier. Daily hemispheric, normal incidence, ultraviolet, and

net exchange data were published in the Monthly Weather Review 1914-49 and Climatological Data National Summary 1950-1972 and 1975-1976. Monthly and period of record averages of hemispheric data are printed in the annual Local Climatological Data by station for the years 1963-71

8. Volume = The digital data are in two families: TD-9726 (Daily) consisting of 5 reels and TD-9725 (Hourly) consisting of 10 reels of magnetic tape. Tapes are 9 track.

For more information address the Director, National Climatic Center, Federal Building, Asheville, North Carolina 28801, or call (704) 258-2850, ext. 683.

Caution: The United States National Weather Service considers the accuracy of these data questionable.

Data described in "Rehabilitated Solar Radiation Data" are recommended over those contained in the old data set.

REFERENCES

- Air Resources Laboratories, 19XX: Geophysical Monitoring for climatic change summary report. NOAA Air Resources Laboratories, U.S. Department of Commerce, Boulder, Colorado.
- V. Cinquemani, J. R. Owenby, & R. G. Baldwin, 1978: Input Data for Solar Systems. Report of the National Climatic Center, U.S. Department of Commerce, Asheville, North Carolina, 192 pp.
- National Climatic Center, 1978: Hourly solar radiation-surface meteorological observations. SOLMET Vol. 1 - User's Manual TD-9724, National Climatic Center, U.S. Department of Commerce, Asheville, North Carolina, 46 pp.
- National Climatic Center, 1979: Hourly solar radiation-surface meteorological observations. SOLMET Vol. 2 - Final Report TD-9724, National Climatic Center, U.S. Department of Commerce, Asheville, North Carolina, 184 pp.
- National Oceanic and Atmospheric Administration, Report & Recommendations of the Solar Energy Data Workshop held November 29-30, 1973: National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Silver Spring, Maryland.
- B. B. Williams, J. R. Cristina, and E. A. Carter, 1979: Solar Radiation Observation Stations, updated to 1979. Kenneth E. Johnson Environmental and Energy Center, University of Alabama, Huntsville, Alabama.

PROXY AND NON-INSTRUMENTAL DATA RESOURCES

Working Group 5

Co-Chairmen: Alan Hecht
George Smith

Members: L. Dennis Delorme
Henry Diaz
Marion L. Parker
Marilyn Shartran
George Smith
Thompson Webb, III
Peter Woodbury

INTRODUCTION

Understanding the climate system and testing reliable climate models requires improved documentation of climatic change on a wide range of time scales (NAS 1978; Hecht 1979). Historic and paleoclimatic studies must therefore be an important research component of the National Climate Program. Such studies place the relatively short meteorological record in the perspective of the historic and geologic past, and provide clues regarding the causes and mechanisms of both short-and long-term climatic variations and changes. In particular, the paleoclimatic record makes it possible to establish the patterns in time and space of changes in the climate that affect the oceans, ice sheets, and continents, and to relate the variations recorded in the sluggish parts of the system that respond to climate to the more rapid variations in the atmosphere and on the land surface.

Historic and paleoclimatic data are derived from both direct and indirect sources. Examples are primary historic documents, geologic and biologic indicators such as variations of the widths of rings in trees, changes in the ratios and abundance of diagnostic flora and fauna in marine and terrestrial environments, and the size of lakes in closed basins.

Over the past 10 years, two major developments have greatly advanced analysis of paleoclimatic data. First, the development of more-precise methods that date paleoclimatic records have provided a firmer chronology for dating past climatic changes. Second, the development of quantitative statistical methods make it possible to relate changes in the many kinds of paleoclimatic indicators to changes in climatic variables. Using such statistics, for example, the

changes of abundance of marine organisms preserved in deep-sea cores can be read as a record of past ocean temperatures.

Analysis of historic climatic data has also been significantly advanced in recent years; but generally, this field of study is handicapped by too few researchers. Historians have a major opportunity to contribute to climate studies by interpreting the older written records that convey climate information from historic sources.

Researchers in paleoclimatology require conventional climatic data to calibrate their paleoclimatic models. This need places certain demands on conventional data centers and requires interaction between these centers and paleoclimatologists.

In the long run, the interests of the National Climate Program are best served by an understanding and appreciation of available historic and paleoclimatic data resources, and by an overall national strategy to augment and preserve this valuable resource.

RECOMMENDATIONS

1. Historic and paleoclimatic climatic data are an essential national resource. An appropriate fraction of national funding for climate research must be designated for the maintenance and expansion of paleoclimatic data centers.
2. Many raw materials from which paleoclimatic information is extracted (e.g., ocean-bottom cores, polar-ice cores, tree cores, and lake-bottom cores) are collected at considerable expense. New measuring techniques, or new ideas on what to measure, frequently call for reexamination of these materials. Funds to ensure their preservation should be provided as an economically sound alternative to re-collection.
3. Data centers currently exist for several types of paleoclimatic data. These centers include the Laboratory of Tree Ring Research (University of Arizona), the Deep Sea Drilling Program (Scripps Institute of Oceanography), and the Glacial Photographic Collection (U.S. Geological Survey, Tacoma). Such data centers should be nationally recognized and maintained with accepted standards for security, documentation, storage, and exchange. In cases where such centers are located at universities, appropriate national funding must be provided to maintain the activities of these centers. Fiscal and coordination arrangements should be made between the paleoclimatic data centers and National data centers to handle the distribution of bulk data requests.

4. Paleoclimatic researchers are users of conventional climatic data. The data centers handling these data are often not able to provide it in a form that is suitable for paleoclimatic research. Conventional data, for instance, are not always adequately documented as to sources, formats, length of records, gaps, levels and types of error, and cautions against misinterpretation. At the same time, paleoclimatologists are not fully aware of all available services provided by conventional data centers. In view of these circumstances, it is recommended that improved methods be developed for making conventional data, and information about the existence and availability of these data, more accessible. Specific examples of conventional data required by paleoclimatic researchers are given in Appendix B.
5. An advisory group on historic and paleoclimatic data representing all areas of paleoclimatic research should be established and charged with identifying data management problems, facilitating interchange between data-bank-management centers, and acting as a technical resource for investigators in need of data management assistance.
6. An inventory of historic and paleoclimatic data should be assembled. This inventory will be prepared in cooperation with International Council of Scientific Unions (ICSU)/International Quaternary Association (INQUA) and it will be international in extent. A survey questionnaire for this inventory is now being prepared.
7. A relatively unexplored facet of paleoclimatic research is the availability and archiving of historic data. There exists therefore, a major opportunity to examine primary historic documents for climatic information.
8. The Global Atmospheric Research Program (GARP) terminology should be extended for describing historic and paleoclimatic data levels as shown below:

<u>Level</u>	<u>Description</u>	<u>Examples of Special Documentation Requirements</u>
0	The physical sample: collected sediment, tree core, or ice core.	Sample identification, sample location.
1	Primary data	
	(a) "raw" observations or measurements: thickness of rings for a particular tree, counts of micro-fossils within written record of lake level.	Descriptions of procedure used for measurement, description of taxonomic classifications used.

<u>Level</u>	<u>Description</u>	<u>Examples of Special Documentation Requirements</u>
1	(b) "final" working data set: data that have been standardized, filtered, or otherwise adjusted for quality - data set used for generating peleo-climatic estimates.	Description of criteria used to average or adjust data and to determine quality of data.
2	Paléoclimatic estimates derived from a particular site.	Documentation of techniques or procedure used to transform primary data, including accuracy.
3	Two or three dimensional fields of estimates, derived from one or more sources of paleoclimatic data.	Description of grid scheme and resolution criteria used to integrate different classes.
9.	All data sets require sufficient documentation and assurance of their accuracies. Specific recommendations for historic and proxy data are given in Appendix A.	

REFERENCES

- National Academy of Science, 1978, Elements of the Research Strategy for the U.S. Climate Program: Report of the Climate Dynamics Panel to the U.S. Committee for GARP, 46 pp.
- Hecht, Alan D. (editor), Paleoclimatic Research: Status and Opportunities, Quaternary Research, July 1978-in press.

APPENDIX A
DOCUMENTATION

A. Data file documentation is of direct concern to:

- (1) Data producers - because they are the primary source of information concerning descriptions and limitations of the data.
- (2) Data (banks) centers - because their repositories and disseminators can provide a useful function in developing practical guidelines for documentation.
- (3) Funding agencies - so that they can require documentation of the specific purpose of their funding.

Documentation can be subdivided into two major types:

- (1) General - not specific to any one data set, and intended primarily as background guidance for outside users.
- (2) Specific - unique to an individual data set.

Each of these types can be further subdivided into two parts:

- (a) Descriptive - what, where, when, how.
- (b) Informative - quality, resolution, cautions, limitations.

B. The requirements for basic data documentation of an individual data set includes as a minimum a title and abstract and some information about the data, tape layout, and data format details.

1. Title

A short name for the data set or sets.

2. Abstract

The length should be not more than a single-spaced page. This abstract can also be used in preparing inventory information about the data. A different abstract will often be needed for the reconstructed climatic grid data, or the map data, as compared to the other data levels. Suggested contents for each abstract are:

- Title, giving data type.
- Whether the data consist of raw material, basic measurements, grid analyses, or maps.
- Number of sites, periods of record, areal extent of sites, spacing of grid points. If different sites have very different periods of record, comment on this.
- Brief comments on data status, sources of errors, limitations on the data, and statements of caution as necessary.
- Approximate data volume.

C. Supplemental information

More detailed information above minimum requirements might include the following:

1. Extended abstract and general information

- Type of data.
- Space-time coverage, e.g., "Thirty lake-bottom core sites, mostly to 7,000 years BP, some 10,000 to 18,000 years, for the eastern U.S.A."
- Quantity of data.
- Map showing locations of sites and lengths of record.

2. Time resolution of data. "Samples taken each 100 years for 3,000 years, then every 500 years."

Note that the minimum sample spacing in time should be appropriate to the type of proxy material involved. If natural processes stir the mud, or if material diffuses through the layers, frequent sampling with depth (time) might not be meaningful.

3. Indication as to whether the data are based on something measured, counted, or weighed.
4. Information about the data gathering process.
5. Comprehensiveness of this data set compared to other available data of this type. Are these data included in more comprehensive sets?
6. Statement about the quality of the data, to include comments on:
 - Quality of control procedures used.
 - Flags, if any, to discriminate general quality of one site vs. another.
 - Approximate level of dating uncertainties. Indication of how subsequent refinement of dates is handled in the data set. Give references as necessary.
 - Cautionary statements about using the data, as appropriate. If users might reasonably think they are getting certain data quality and quantities which they aren't, caution them on data quality and data gaps.
7. Procedures:
 - Procedures used to adjust the data, or to make climatic estimates. Give references for details.
 - What data (coverage) were used as input to the reconstruction?
 - Comments on the spatial representativeness of the data.
 - Is the "site" just one sample of a consolidation of several?
 - What is the geographic variability of samples from neighboring sites?
 - What is the amount of spatial variability of samples from neighboring site?

D. Tape layout and formats

- Information on tape density, number of tracks, and character code. Note if the archive tape may be different from the tape sent to the user.
- File structure of the tape including number of files header format, length of physical records, and blocking factors.
- Number of records, if known.
- Structure and logical layout of a record, including location, size and content of each data field.

E. Data flags

Information on the quality of data would allow sample sites or paleoclimate information to be used with different weights (or not used) in a given reconstruction.

F. Data separation

Since formats are quite different for Level 3 data compared to Levels 1 or 2, these types of data should be kept in separate files or on separate tapes.

G. Documentation within a laboratory

For each data set, the basic documentation should be in a small folder which includes:

1. Tape numbers and backups that have the data. Usually a tape creation date also is desirable.
2. The data set writeup.
3. Pointers to more detailed inventory listings.
4. Dates when changes were made to the archive and what the changes accomplished.
5. Pointers to simple computer programs that can be used to access the data.
6. The computer program used in each processing step.
7. Pointer to the program listings that accomplished the processing step.
8. Dates when data were sent to users and which version of the data was sent in each case.

9. Pointer to a more detailed set of publications.
10. Pointer to data listings on print or microfilm.

If there are many data sets in the laboratory, a listing of data set names, perhaps including abstracts, will be useful.

APPENDIX B

Paleoclimatologists need to know what conventional data regarding the present climate are available, what form the data are in, how they can be obtained, and what are the costs to the user wishing to obtain them. At present, more complete information is needed in all such respects, as well as information on the spatial coverage and resolution of readily available data sets.

For example, the following data sets are of use to paleoclimatic researchers, but are not readily available:

1. Uniformly accepted global record of ocean-surface long-period average temperatures.
2. Standardized record of long-period mean surface albedo values.
3. Divisional averages of climatic data for years prior to 1931.
4. Measurements on the isotopic content of precipitation.
5. Monthly soil temperatures.
6. Long continuous records of temperature and precipitation in monthly averages from 1700 to present for use in snowline and glaciological studies.
7. Mean ablation-season temperatures and mean accumulation-season precipitation in alpine regions.
8. Altitudes of summer freezing temperature levels.
9. Mean lapse rates and their inter-annual and inter-decadal variance for various types of climate areas.
10. Thirty-year averages of monthly data for the cooperative network of U. S. stations, including mean maximum temperatures, mean minimum temperatures, number of days with 0.01 inches of rain, number of days with 0.5 inches of rain.

While in some cases work is in progress, to make the above data sets available, there are data problems which also need to be corrected. Specifically:

- Individual pieces of data missing from tape or other storage media files should be filled in. The missing values are often recoverable from a hard copy document.
- The data currently available on tape need to be better organized and documented.
- The data need to be supplemented, where possible, with an updated edition of station or sub-station histories.

GEOGRAPHICAL, LAND USE, AND ASSESSMENT DATA

Working Group 6

Chairman: James R. Anderson

Members: Robert Bailey
Raymond B. Daniels
John E. Estes
Fred B. Warren
Arthur Woll

INTRODUCTION

Working Group 6 of the Climate Data Management Workshop held at Harpers Ferry, May 8-11 was assigned the following topics:

Land Use and Land Cover -- James R. Anderson
Vegetation Types -- Robert Bailey
Soils -- Raymond B. Daniels
Land Elevation and Surface Roughness -- Arthur Woll
Crop Acreages, Yields, and Prices -- Fred B. Warren
Population (Number, Distribution, Trends, etc.) --
James R. Anderson
Use of Remote Sensing Technology for Acquisition of Data --
John E. Estes
Biomass Amounts and Changes
Energy Production and Use

The selection of members of Working Group 6 was made with the intention of providing appropriate expertise on each of the topics assigned to the Working Group. However, William Osburn from the Department of Energy was unable to participate in the Workshop. Therefore, no presentation on biomass amounts and changes, and energy production and use has been made in this report as originally planned.

Tasks assigned to Working Group 6 were to:

1. Develop an inventory of geographical and related data sources.
2. Make a preliminary assessment of the existence and quality of available geographical and related data sources to determine the relationships of these data sources to the requirements for such data for use in climate research, modeling, and impact assessment.
3. Submit recommendations to enable appropriate and effective use of existing and any additional data needed in climatic studies.

A review was made of the requirements, uses, and needs for geographical, land use, and assessment data in climatic studies from the following sources of information:

Jenne, Roy L., The Global Data Base for Climatic Research: A Report to the WMO-ICSU Joint Organizing Committee for the Global Atmospheric Research Program (GARP), Preliminary draft dated 23 November 1978.

Public Law 95-367--95th Congress--Sept. 17, 1978 (National Climate Program Act).

Draft Preliminary 5-Year Plan--National Climate Program, March 28, 1979.

The Global Atmospheric Research Program (GARP) Climate Dynamics Sub-Programme: Report of the Meeting of the Joint Organizing Committee (JOC) Working Group on Land Surface Processes, Dublin, 8-12 May, 1978. Published in Geneva, December 1978.

Climate Data Requirements, Uses, and Needs of Federal Agencies and State Climatologists based on papers submitted and presentations made at the Climate Data Management Workshop, Harpers Ferry, May 8-11, 1979.

Generally, geographical and related data will be used in: (1) conducting climatic research (i.e., how changes in biomass affect the CO₂ content of the atmosphere); (2) atmospheric and hydrologic modeling; (3) making climate impact assessments (i.e., the impact of a 3-year drought on crop production in the Great Plains); (4) climate related programs of the Department of Commerce, Department of Agriculture, Department of Energy, Department of Defense, Department of the Interior, Department of Housing and Urban Development, Department of State, Council on Environmental Quality, Environmental Protection Agency, National Science Foundation, National Aeronautics and Space Administration, State Climate Program Offices of the 50 States, and the private sector.

Data Requirements

Some specific requirements or uses of geographical and related data are:

1. Statistics on the areal distribution of soils and their physical and mineralogical properties relating rainfall, evapotranspiration data, etc. for climatic research, hydrologic modeling, and impact assessments.
2. Destruction of biomass in relation to the CO₂ problem.
3. Distribution of the use of fuels of different types in relation to air pollution conditions.

4. Energy release rates in relation to land use, land cover, socio-economic, demographic, and biophysical patterns.
5. Vegetation type, land cover, surface roughness, elevation data for use in the modeling of land surface processes as these influence climate.
6. Data on terrain features, land use and land cover, soil surface properties and soil moisture, vegetation types, etc., is needed for studies on the albedo, roughness height, and climatic impact assessments.
7. Average terrain data is needed for synoptic state atmospheric modeling.
8. Vegetation type and density are important data sets for the indirect estimation of global hydrologic data.
9. Constant parameters that describe the properties of the land surface are required as input to general circulation models.
10. Analysis of climatic states or variations in physically explaining climatic variations, in predicting, and in developing and testing models for predicting variations or in assessing impacts of climatic variations on economic, social, or ecological conditions.
11. Historical crop areas and yields can be used, together with soil and topographic information, to model the possible effects of climatic fluctuations on future production of food and fiber.

Data Quality and Constraints

Although it is difficult to be too specific about quality and constraints of geographical, land use, and assessment data, a number of generalizations may be made:

1. The vast majority of these data are compiled with no thought of their use for climate related purposes.
2. These data are highly variable in terms of: spatial scales (levels of generalization), terminology (concepts of classification), temporal scales, methods of data display and the accuracy not only of the data but in the representation as well (map and/or tabular or statistical form).
3. Few of these data are global let alone continental or even national.

4. Gaps in coverages and inconsistencies in classification schemes, grids and projections employed along with the factors mentioned in 1 to 3 above makes comparison of such data difficult even for data which purport to display the same or a similar theme (e.g., soils, vegetation, land use).

Data Formats

Geographical, land use, and assessment data are generally presented in maps and statistical tabulations. Maps of soils, vegetation types, land use and land cover are widely produced and used for many different purposes. Some soil characteristics may also be presented in statistical formats. Tabulations showing areas occupied by different categories of land use and land cover have generally been available for counties and States in the United States. Crop areas, yields, and prices are generally presented in tabulations. Remotely sensed data are now becoming widely available in both digital and analog formats. Similarly, data on topography, soils, vegetation types, land use and land cover, and crop areas, yields, and prices are becoming more widely available in digital formats.

Presently, land use and land cover maps and soil maps are being digitized in polygon formats by the U.S. Geological Survey and the U.S. Soil Conservation Service. Formerly and still in some State and Federal agencies such maps are being inputted into geographic or georeferenced information systems in grids of various sizes. Initially, this approach was used by the U.S. Geological Survey. However, when users began to ask for data by grid squares ranging from one acre to one square mile or more, it was soon realized that such an input procedure lacked needed flexibility in using the data. Therefore, a change to digitizing the actual boundaries of different categories of land use and land cover was made. Then software programs were developed to grid the maps that were in polygon formats to produce cells or gridded areas of various sizes. Thus the data can be delivered to users at varying scales of generalization, which has proved to be much appreciated.

USE OF REMOTE SENSING

The inventory, analysis, and assessment of surface cover types and the level of human use of land encompasses the application of information from many disciplines, including agriculture, hydrology, forestry, rangeland management, oceanography, demography, sociology, economics, climatology, geology, and

geography among others. Remote sensor systems designed for environmental monitoring attempt to detect, identify, monitor, map and measure parameters that affect the complex relationships of peoples' interactions with their surroundings. This may involve the direct interpretation of the areal extent of snowpack of the mountains of the western United States, or use of remote sensor data as surrogate or proxy parameters for getting at information not directly observable from space (e.g., inferring amounts of irrigation waters applied from an identification of crop types in irrigated agricultural areas in arid regions of the southwestern United States). Today manual and semi-automated cartographic techniques are employed in planning, implementing, and monitoring nearly every parameter and/or activity involving human interaction with the physical environment (NAS/NRC, 1976). These data exist for many areas, or a wide variety of themes, at diverse scales and levels of accuracy. Inventorying, formatting, and processing these data for use in climate investigations is a difficult task. In recent years, however, we have developed the remote sensing capability to map land use and land cover categories at regional scales for nearly the entire world.

LANDSAT data are potentially available for all areas from essentially 85°N latitude to 85°S latitude. We certainly can provide categories of land use and land cover data at scales and levels of specificity compatible with the need for climatic modeling at global, national, state, and regional levels within reasonable time frames. This program has been acquiring data for the United States and many areas of the world since July 1972. Many areas have been covered many times, and some areas of the globe have yet to be covered as no requirement to do so exists. Remote sensor data from LANDSAT* employed together with data from collateral sources offer the potential of providing data on current and changing land use and land cover patterns in either digital and/or analog form. These data can be structured and placed into georeferenced information systems so that the functional and spatial dynamics of land resources and their relationships to fluctuations in climate may be effectively and efficiently studied.

In evaluating the existing LANDSAT data on a global, continental, and local basis it is important to remember the inherent nature of the data itself. LANDSAT data in digital or analog form contains information on a variety of parameters. Until these data are processed, analyzed, interpreted, and the significance and accuracies of the interpretations verified, their use will be limited.

*

Radiometer data on the AEM01 satellite is covered in another Working Group Report.

Some gaps do exist in LANDSAT coverage at the global scale. Good data coverage exists for the United States, Canada, and Mexico. Very good data coverage exists throughout the United States, except for parts of Alaska and Hawaii. LANDSAT data are or can be made available in common analog and digital formats for use at a variety of scales. Although the data are typically formatted into images 185 km x 185 km, both analog and digital mosaicing capabilities exist which can provide accurate data sets of varying spatial dimensions. These data can be registered to a variety of coordinate systems. It should be emphasized, however, that this capability, although proved for areas as large as a State (e.g., California, Arizona), have not been tested on a national level as yet. In addition the costs of compiling, processing, registering, and storing such digital data sets at the present time would be considerable. Thus, while analog LANDSAT data may be somewhat more difficult to register, interpret, digitize, and reformat for input into climatic models, it may be a cost-effective alternative for producing land use and land cover data for large areas for use in climatic studies. Indeed, analog LANDSAT mosaics currently exist for several States in the United States (e.g., California, Nevada, Utah, New Jersey, Florida, and Georgia) and several countries (e.g., the United States, Mexico, Italy, and Algeria). Companies such as Earth Satellite Corporation, General Electric, and IBM all have produced such mosaics in the past and continue to do this kind of work.

Accessibility - Information on how to obtain LANDSAT data for anywhere in the world may be obtained from: EROS Data Center, United States Geological Survey, Sioux Falls, SD 57198.

Quality of Data - Although the quality of LANDSAT data is uniformly high, depending upon whether the user requires raw, uncorrected, or radiometrically and geometrically corrected data, a variety of problems may exist when using a particular data set. The nature and extent of these problems can be ascertained through contacts with personnel of the User Services Division of the EROS Data Center, Sioux Falls, SD 57198.

For all areas within range of ground receiving stations (and there are now a number of them in operation around the world and more are planned), data are potentially available every 18 days at present, weather permitting. For areas outside the range of tracking stations data availability is limited at present by the use of wide band video tape recorders. These recorders have been a handicap inhibiting progress towards total coverage for the area of the Earth beneath the orbits of the LANDSAT satellites; however, future implementation of a Tracking Data Relay Satellite System (TDRSS) will free coverage from tape recorder dependence and open the way to more effective global acquisition of LANDSAT data.

Processed but unanalyzed LANDSAT data are currently readily available and accessible in raw form on a global, continental, and local basis through the EROS Data Center in Sioux Falls. By "unanalyzed" it is meant that no thematic classification of these data has yet been done. As such, the potential user of information from this data set will either of necessity become aware of the problems inherent in thematic classification of these data in a manual or semi-automated mode or contact or contract with someone who is knowledgeable.

If the users themselves are to work with these data, they should be aware that manual image interpretation procedures can be obtained by referring to Chapter 14 of the Manual of Remote Sensing, of the American Society of Photogrammetry. (Estes and Simenett, author-editors 1975). In the area of semi-automated analysis the user should be aware that many factors affect the ability of a machine to accurately provide a thematic classification of LANDSAT data. Among these factors are: the classification scheme itself, feature development and selection, preprocessing functions, generation of class training statistics, classification algorithms, and performance evaluation.

For more detail in each of the above the reader is referred to Appendix

Once LANDSAT data have been classified they should be rectified, registered, and input into some type of georeferenced data base for most efficient use of land use and land cover data with other data sets used in climatic modeling.

SOILS

Soils are the medium of plant growth and are a physical, chemical, and biological interface between the atmosphere and the underlying geologic materials. The soil climate, material from which the soils are derived, vegetation, and site history all have an influence upon the kind of soil found at any one point. When these factors are reasonably uniform over an area, the same soil, or closely related soils are found. A soil map is an attempt to show those parts of the landscape that have had a reasonably uniform soil environment. Because no area of the Earth's surface is uniform, soil maps show the distribution of mapping units that, while not uniform, are dominated by one or two kinds of soils. The inclusions of other soils depends upon the complexity of the hydrologic and geologic factors, the scale of mapping (soil maps at a scale of 1:20,000 do not show areas smaller than 5 acres) experience of the mapper, and purpose of the survey. Mapping units are named for the dominant or co-dominant taxonomic unit(s). Interpretations for a map unit are based upon the taxonomic units present. Soil survey pedon data are classified by taxonomic unit.

Soil survey data in the form of maps, descriptions, and laboratory data are available for most of the world through FAO-UNESCO. There are large variations in quality and density, especially in areas where little detailed mapping has been done as contrasted to areas where soil surveys of varying intensity have been made for 80 years or more.

Soil survey data in the United States and Canada are abundant and of excellent quality. Although different classification systems are used in the two countries, it is relatively easy to correlate soils between the systems. Abundant published and unpublished physical, chemical, and mineralogical data are available in both Canada and the United States. Interpretations of soil data and map units are well advanced in both countries.

If the FAO-UNESCO soil map of the world were digitized, much useful soil data would be available for climatic studies.

In the United States, soil map data should be digitized and expanded on natural regional soil zones such as major land resource areas or physiographic areas. A similar approach should be used for the Canadian soil survey data.

Plant available water has been measured for several soils and can be predicted from other physical properties of soils. Extrapolation of data for studies that need soil moisture estimates should be made based upon major land resource areas, not upon political boundaries.

VEGETATION TYPES

Vegetation may be defined as the mosaic of plant communities in the landscape (Kuchler 1964). It consists of a given combination of life forms (trees, shrubs) and a given combination of taxa (genera, species) with relatively uniform ecological requirements. Numerous classifications of vegetation are in use. Each of the many natural resource-related disciplines has numerous classifications, each land management agency has several systems, and each geographic area varies in the applicability and use of different classifications. The same types are sometimes described by different terms, and some terms are applied with numerous meanings. Many countries have been making maps of vegetation types for many years. The three-volume International Bibliography of Vegetation Maps (Kuchler 1965) contains hundreds of entries. They vary in scale, projection, and principle of classification so that transforming one system into another one is extremely difficult or impossible.

There are two basic approaches to the problem of classifying vegetation types. First, there is potential natural vegetation. This approach views vegetation in terms of which type would exist today if man were removed from the scene and if plant

succession were telescoped into a single moment. Its value derives from the indication it provides of the biological potential of all sites.

The second way of classifying vegetation is by the actual, or real, vegetation that occurs at the time of observation. It may be natural (not appreciably affected by man), seminatural, or cultural vegetation depending on the degree of human interference. Such schemes have wide application because they are of value not only to users of the vegetation itself such as foresters, but also to those who view vegetation mainly as an obstacle, a source of cover, or an amenity.

The problems involved in developing a standardized approach to vegetation classification in all its complexities are not likely ever to be solved. However, it is not necessary to solve these problems completely and practical solutions have already been made. A good example of this is the UNESCO system for classifying and mapping of vegetation (UNESCO 1973). It is designed to map the world's vegetation at the scale of 1:1,000,000 or smaller. While the classification is intended primarily for the preparation of new maps, it may also be used for transforming existing vegetation maps into this system. Maps for the continents of Africa and South America at a scale of 1:5,000,000 are in preparation for world-wide comparison. The classification is based primarily on physiognomy and structure of vegetation.

At the continental level, potential vegetation maps have been developed using standardized definitions for the United States (Kuchler 1964) and Canada (Rowe 1972). Forest cover-type classifications have been developed on the basis of the composition of tree species in a stand. A national classification was published by the Society of American Foresters (1954). The Forest Survey staff of the U.S. Forest Service has developed a similar classification for analyzing timber inventory data. Forest community classifications (based on tree and undergrowth composition) have been developed for many geographic areas, by numerous criteria, and for many purposes. A relatively standard approach in the western United States is the "habitat type" classification developed originally by Daubermire (1952), and extended now to at least half of the forested lands in the West by the U.S. Forest Service (Pfister 1976). None of these data are available in digital format.

The Forest Service is by no means the only organization to publish vegetation maps. Both Federal and State agencies have become aware of their usefulness and, as a result, the number of vegetation maps has grown enormously. The Bureau of Land Management, the Soil Conservation Service, the Fish and Wildlife Service, the National Park Service, river basin authorities, planning agencies, state geological surveys, and others have undertaken their preparation.

Small-scale mapping is essential in order to tie various parts of continents together and establish the bases for detailed climatic research. Therefore, efforts should be made to expedite the UNESCO Mapping project, particularly for North America. Along these lines, a pilot project to determine the usefulness of LANDSAT data in vegetation mapping should be initiated. A study should also be undertaken to determine if the UNESCO classification of vegetation lends itself not only to the scales for which it was designed but also to much larger ones. Large-scale mapping is needed just as urgently as mapping at small scales or even more so. As a framework for coordinating this work, a study should be conducted to determine the feasibility or transforming existing maps into the UNESCO system for use in climatic research, modeling, and impact assessment.

LAND USE AND LAND COVER MAPS AND DATA

As used in this report, land use refers to "man's activities on land which are directly related to the land" (Clawson and Stewart, 1965). Land cover, on the other hand, describes "the vegetational and artificial constructions covering the land surface" (Burley, 1961). Also included in the concept of land cover are areas of barren land and perennial snow or ice. Many countries have been making land use and land cover maps and collecting statistical data for many years. Yet today there is really not a good worldwide set of land use and land cover maps. Therefore, there is no common global set of land use and land cover data that can be keyed to relatively small areas of the Earth's surface. Likewise no such maps or data are available for the North American continent. Thus data in digital format suitable for climate research, modeling, and impact assessment do not exist on a global or continental basis at the present time.

The capability to make maps and obtain data pertaining to land use and land cover has improved rapidly in the past 2 decades. Developments in remote sensing equipment, interpretation techniques, and data processing now make it possible to produce the maps and data that are needed for climatic studies. Also present is a growing recognition that some degree of standardization in classification of land use and land cover is important if a really comprehensive and useful data set is to be obtained over extensive areas of the world (Anderson et al. 1976).

Although many individual countries such as those of western Europe and Japan have very good land use and land cover maps and data, there are really no such maps in the scale range of 1:250,000 to 1:1,000,000 for the world as a whole from which statistical data can be extracted. Data on land use and land cover collected by using enumeration techniques such as for the United States Census of Agriculture are available

only at the county level, which means that only a very gross generalization of land use and land cover patterns is possible. Similarly the Conservation Needs Inventories carried out under the lead of the U.S. Soil Conservation Service in 1958 and 1967 by taking an average 2 percent sample of the total area of the United States, may not yield data suitable for gridding into 10 feet x 10 feet squares such as those being used by the Office of Climatology of the U.S. Navy (Conservation Needs Inventory, 1967).

The only maps of land use and land cover for the world as a whole were published in the World Atlas of Agriculture (World Atlas of Agriculture, 1969). Map scales are either 1:2,500,000 or 1:5,000,000 depending upon availability of information for the preparation of the maps. Sixteen main categories of land use and land cover are shown. These include arable land, woods and forest, rough grazing land, and non-agricultural land such as urban areas. Although these maps of land use and land cover in this Atlas were carefully compiled, there simply was not enough existing information to make more detailed maps at the time the Atlas was prepared.

Turning to North America, land use and land cover data are becoming available at scales appropriate for coverage of the United States and Canada. However, at the present time neither country is completely mapped. In the early 1960's land use maps for the more densely settled part of Canada or about 800,000 square miles were prepared at a scale of 1:50,000. These were later generalized to a scale of 1:250,000 and then digitized. Ten major categories of land use were identified from aerial photographs (McClellan and others, "A Guide to the Classification of Land use for the Canada Land Inventory, Department of Regional Economic Expansion", unpublished report, Department of Energy, Mines & Resources, January 1968). The digital data which is stored on magnetic tape at either 1600 or 6250 bpi consists of 750 million bytes of data. No land use and land cover mapping comparable to that done for the more densely settled part of Canada is available for the remaining 3 million square miles of Canada.

For the United States, the U.S. Geological Survey is preparing and publishing land use and land cover maps for the entire Nation at a scale of 1:250,000, except for a relatively small part of the country, which will have maps published at 1:100,000. These maps are being compiled from remotely sensed data using a classification system that has a framework of 9 general Level I categories that are further subdivided into 37 more specifically defined Level II categories (Anderson et al. 1976). The land use and land cover mapping is to be completed by 1982 with an update of the more dynamic parts of the country to begin in 1980. Approximately 1.7 million square miles of the 3.6 million square miles in the United States have already been mapped. The maps are being digitized in a polygon format. Polygons can be converted to grid cells of varying sizes when desired. A computerized geographic

information system has been developed to store and retrieve data for analytical and other uses (Mitchell et al. 1977). Digital tapes are now available for about 600,000 square miles of the United States.

The land use and land cover maps and data which are available for parts of Canada and the United States are of high quality for use in climatic studies. The maps and digital tapes are readily accessible. However, the use of land use and land cover maps and digital data in climatic research, modeling, and impact assessment will probably require adaptations in data formats. Considerable flexibility exists once such data have been incorporated into a geographic information system, which should make it possible to accommodate reformatting needs more easily.

At the local level many land use and land cover type maps have been made by city, county, and multicounty regional planning agencies. Such maps vary greatly in quality and many would not be very useful for micro-level climatic studies. In rural areas very little has generally been done to map land use at larger scales such as at 1:24,000. Some digital data are available for land use at local or micro-scales. Such data would generally be found in city, county, or multicounty regional planning offices. The U.S. Geological Survey has been conducting studies which may provide guidance for using land use and land cover data in micro-level climatic studies (Reed and Lewis, 1978).

It is also necessary to recognize the need for adding new categories or combining categories in existing data bases in order to accommodate specific needs. For example, Working Group 2 in addressing the need for land use and land cover data to develop, test, and verify climate models that include a dynamically coupled land-atmosphere interface identified the need for the following categories of land cover: vegetal canopy density (including seasonal variations, species or broader biological groupings, density of urbanization, density of agricultural activity (intertilled crops, close sown annual crops, hay crops, and pasture. Sometimes useful data surrogates can be derived from existing categorizations. In other instances new categories may need to be mapped.

TOPOGRAPHY

(Land Elevation and Surface Roughness)

Several data sets are available that give hypsographic data by geographical location. These data sets may be in a digital or map format giving contours and spot elevations.

Digital terrain tapes have been developed from 1:250,000 scale base maps with available elevation spot locations every 200 feet. There is complete coverage of the United States and a major part of Europe and Korea has also been completed. The record is on a multifile 9-track magnetic tape with odd parity at 1600 bpi.

The Defense Mapping Agency has several small-scale maps available to the Executive Branch of the U.S. Government for global use. The relief is usually shown by contours or gradient tint with heights in meters. Map scales range from 1:1,000,000 to 1:5,000,000 and stated contour intervals of 200 and 1000 meters. Status maps are available showing 44 maps by geographic area and by scale. None of the elevation data is in a digital format.

The U.S. Geological Survey has a basic topographic map series at a scale of 1:24,000 with gradual future conversion to 1:25,000. Such maps should have applications in some micro-climatic studies. These maps present the following elements by geographic location: hypsography (including contours and spot elevations), vegetation (woodland) - culture, hydrography, and boundaries. The usual contour interval is 10 and 20 feet, where not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval.

A concerted effort is underway to digitize elevation data from 1:24,000-scale photoimage bases.

The U.S. Geological Survey has a 1:250,000-scale topographic quadrangle series. The digital terrain tapes referred to above were to be made from this series. It is the largest scale series for which maps are available for the entire United States. Because of the emphasis in climatic studies on digital formats, this map series is an important one.

The new USGS 1:100,000-scale topographic maps have very limited coverage at this time. However, rapid progress is being made in producing such maps for the United States except for Alaska, which does not yet have the 1:24,000-scale base maps from which the 1:100,000-scale series is being derived.

CROP AREAS AND YIELDS AND PRICES RECEIVED BY PRODUCERS

Principal sources of data on crop areas and yields, both in the United States and in other countries, and prices received by producers are as shown on the following page.

<u>Data Set Name</u>	<u>Contents</u>	<u>Contact</u>
USDA Official USA Estimates	Crop area and yield estimates to the country level within the U.S. Prices received at the State level, from 1866.	Data Services Branch Survey Division Economics, Statistics and Cooperatives Service U.S. Dept. of Agriculture Washington, D.C. 20250 202-447-7017
USDA Foreign Crop Estimates	Crop areas and yields for all foreign countries, from 1960.	Data Systems Division Foreign Agricultural Service U.S. Dept. of Agriculture Washington, D.C. 20250 202-447-5255
CANSIM (Canadian Socio-economic Information Management)	Canada yield, acreage, energy supply/demand, fish catch population and price indices.	Mr. Michael Williams User Advisory Services Division Statistics Canada 25 St. Clair Avenue, East Tenth Floor Toronto M4T 1M4 CANADA Phone: 966-6574

Information Management

United States: Official U.S. Department of Agriculture estimates for the following crops grown in the United States are available in the following formats for all years beginning with the year indicated below.

<u>Item</u>	<u>Magnetic Tape</u>	<u>Tabular</u>
Major crops, including potatoes	1954	1866
Non-citrus fruits	1963	1889
Tree nuts	1963	1909
Citrus	1974	1909
Vegetables	1969	1919
All other crops	1975	varies
Prices received by farmers	1978	1866
County estimates	1972	mid-1930s

Information on the areas and yields of crops in foreign countries is contained in an online indexed sequential file by the U. S. Department of Agriculture. This file may be accessed directly through remote terminals or copied onto magnetic tape. Data for some earlier years are also available in tabular form. Insofar as possible, the data in the file are official estimates released by the individual countries. The quality of these estimates varies from very good to otherwise, depending upon the country. If official estimates are not available, then the "best available" data, e.g., attache reports, trade publications, or inhouse estimates are used. This file is updated monthly to reflect changes in current prospects and to revise historical data as better estimates become available. This file has only country level data.

Canada maintains crop area and yield data, energy requirements, and other data for the different provinces in an online file.

The Center for Environmental Assessment Services (CEAS) of the Environmental Data and Information Service, National Oceanic and Atmospheric Administration at Columbia, Missouri, has sub-national yield and weather data for major crops in the following countries: Argentina, Australia, Brazil, Peoples Republic of China, and the Soviet Union. The data are in computer processible form.

Until 1964, crop area and yield estimates in the United States were based upon a combination of non-probability mail survey indications plus, in some States, State Farm Censuses, and were benchmarked against the national 5-year Censuses of Agriculture. Since 1964, the State and national estimates of crop areas, and the yields of major crops, have been based largely upon probability surveys. Relative sampling errors of the major crops (corn and wheat) have been less than 2 percent at the national level and are in the 4 to 6 percent range for most major states. Country level estimates of land area in crops are mostly derived from non-probability mail survey indications and are less reliable than the State or national estimates. (Statistical Reporting Service, 1975)

Quality of the individual yield estimates is highly correlated with the proportion of the crop which passes through recordable marketing channels. Therefore, the national estimates of yield for food grains and for cotton would be the most accurate, those for feed grains would be less precise, and yield estimates for the various types of forages would be least accurate. As with the yield data, the quality of the estimated prices received by farmers would be correlated with the proportion of the crop which passes through recordable market channels and would be more accurate at the national than the State level.

The ESCS data base is also updated monthly to reflect current changes in potential production and to revise historical data as indicated.

CEAS also has yield and weather data at the crop reporting district (sub-state) level for major crops (wheat, corn, soybeans, and barley) in major producing States.

Major gaps in these data bases would include:

- Much historical data are not in computer processible form.
- In most foreign countries, there is a dearth of information about prices received by farmers and about areas and yields of crops at sub-national levels.
- In the United States, there is a potential need for site specific data which would include such data as soil characteristics, crop yields, weather, and cultural practices, over years. There is now a multi-agency effort within the U.S. Department of Agriculture to establish minimum requirements for, and to establish a point specific data base for crop modeling research work. The leader of this effort is Dr. Donald E. McCormack, Director, Soil Survey Interpretations Division, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C., Telephone 202/447-9218.

In order to make effective use of the historical crop data, foreign data for years before 1960 should be converted to computer processible form. There should also be a continuing project to secure crop data, at least currently, at the sub-national level in foreign countries. Also, presently undigitized historical crop data for the United States should be added to the computer data banks as it is needed by climatic researchers.

POPULATION DATA

Population data are available for all of the world's nations. However, there are great variations in quality, particularly on such characteristics as age, per capita and family income, ethnic origin, race, and level of education. Even the actual number of people occupying given areas in some countries is not very reliable. Generally the most reliable data on actual number of people are available for the large metropolitan areas. Excellent population data are obtainable for Western European countries, Japan, Canada, the United States, South Africa, and some other countries in various parts of the world. For example, Brazil and Costa Rica have much better population data than some other Latin American countries. The Population Reference Bureau of Washington, D.C., annually provides a very useful and reliable "World Population Data Sheet." Of course, the data are obtained

from the most reliable available sources, which as previously indicated vary greatly from country to country. Data include:

- Rate of natural increase
- Population projection to the year 2,000
- Infant mortality rate
- Population under 15 years
- Population over 64 years
- Life expectancy at birth
- Urban population
- Per capita gross national product

For the more advanced countries population data are available in digital format.

Canada and the United States have excellent population data compared with the world as a whole. The actual counts of number of people are reasonably accurate, although problems do exist in obtaining a complete enumeration in inner city areas and in some rural areas such as on Indian reservations. More difficulty exists in obtaining accurate population data on race, ethnic origin, per capita, and family income, and level of education.

In 285 standard metropolitan statistical areas (SMSA) data are available for census tracts which are small areal units that sometimes are less than a square mile (640 acres) in size. Such data are published in Urban Atlases which are available for 65 metropolitan areas. Nearly all population data in the United States and Canada are available in digital format. It is suggested that some carefully designed pilot studies be initiated to test the usefulness of population data in digital formats, particularly metropolitan areas for climatic studies.

RECOMMENDATIONS

1. Explore the feasibility of preparing generalized land use and land cover maps and digital data for the world from LANDSAT data for use in climatic modeling and impact assessments.
2. Initiate a project to examine the practicality of digitizing data from existing global and national thematic maps such as the FAO global soil survey and the UNESCO vegetation type maps.
3. Undertake a pilot project to obtain crop area and yield data for selected homogeneous areas in other countries to facilitate more effective use of such data in climatic

studies. Also improve the use of the present U.S. system of county estimates of crop areas and yields in climatic impact assessments.

4. Initiate a pilot project to merge, generalize, and grid existing digital data in polygon formats such as land use and land cover maps and terrain data for use in climatic modeling.
5. Conduct experiments of limited scope with existing remotely sensed data and available digital land use and land cover data to determine if specific categories of land use and land cover such as seasonal variations in vegetal canopy density can be extracted on a cost-effective basis.
6. Expedite the UNESCO mapping of vegetation types through the use of different kinds of remotely sensed data including LANDSAT and high resolution color infrared photography.

SELECTED REFERENCES

Use of Remote Sensing

- Anderson, J. R., Hardy, E. E., Roach, J. T., and Witmer, R. E., 1976, A land use and land cover classification system for use with remote sensor data: U. S. Geological Survey Professional Paper 964, 28 p.
- Estes, J. E. and Simonett, D. S., 1975, Fundamentals of image interpretation, in Reeves, R. G., ed., Manual of remote sensing, v. 2--interpretation and applications: Falls Church, Va., American Society of Photogrammetry, p. 869-1076.
- National Academy of Sciences/National Research Council, 1976, Research and environmental surveys from space with the thematic mapper in the 1980's, Land Use Management: National Academy of Sciences, p. 43-51.
- U.S. Urban Renewal Administration, Housing and Home Finance Agency, and Bureau of Public Roads, 1965, Standard land use coding manual, a standard system for identifying and coding land use activities: Washington, D. C., Department of Commerce, 111 p.

Soils

- Canada Department of Agriculture, 1976, Glossary of terms in soil science: Canada Department of Agriculture publication no. 1459, revised, 44 p.
- Canada Department of Agriculture, Research Branch, 1978, The Canadian system of soil classification: Canada Department of Agriculture publication no. 1646, 164 p.
- Soil Survey Staff Bureau of Plant Industry, Soils, and Agricultural Engineering, 1951, 1962, Soil survey manual: Washington, D. C., U. S. Department of Agriculture Handbook no. 18, 503 p.
- Soil Survey Staff, Soil Conservation Service, 1962, Soil survey manual: Washington, D. C., U. S. Department of Agriculture, Supplement to Handbook no. 18, replacing pages 173-188.
- _____, 1975, Soil taxonomy, A basic system of soil classification for making and interpreting soil surveys: Washington, D. C., U. S. Department of Agriculture Handbook no. 436, 754 p.
- Working Group on Soil Survey Data, 1975, The Canadian soil information system (Can SIS) manual for describing soils in the field: Ottawa, Ontario, Canada Department of Agriculture, Soil Research Institute, 170 p.

Vegetation Types

- Daubenmire, R., 1952, Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification: Ecological Monograph, v. 22, p. 301-330.
- Kuchler, A. W., 1964, Potential natural vegetation of the conterminous United States (map and manual): American Geographical Society, special publication 36, p. 116.
- _____, ed., 1965-68, International bibliography of vegetation maps: Lawrence, Kansas, University of Kansas Library Series, no. 21, 26, and 29.
- Pfister, R. D., 1976, Land capability assessment by habitat types, in America's Renewable Resource Potential - 1975, the turning point: Society of American Foresters, National Convention, Washington, D. C., 1975, Proceedings, p. 312-325.
- Rowe, J. S., 1972, Forest regions of Canada: Ottawa, Canadian Forest Service Publication 1300, 172 p.
- Society of American Foresters, 1954, Forest cover types of North America (exclusive of Mexico): Washington, D. C., Society of American Foresters, p. 67.
- United Nations Education, Scientific and Cultural Organization, 1973, International classification and mapping of vegetation: Paris, United Nations Education, Scientific and Cultural Organization, p. 37.

Land Use and Land Cover

- Anderson, J. R., Hardy, E. E., Roach, J. T., and Witmer, R. E., 1976, A land use and land cover classification system for use with remote sensor data: U. S. Geological Survey Professional Paper 964, 28 p.
- Burley, T. M., 1961, Land use or land utilization?: Professional Geographer, v. 13, no. 6, p. 18-20.
- Clawson, Marion, and Stewart, C. L., 1965, Land use information, A critical survey of U.S. statistics including possibilities for greater uniformity: Baltimore, Md., The Johns Hopkins Press for Resources for the Future, Inc., 402 p.
- Mitchell, W. B., Guptill, S. C., Anderson, K. E., Fegeas, R. G., and Hallam, C. A., 1977, GIRAS: A geographic information retrieval and analysis system for handling land use and land cover data: U.S. Geological Survey Professional Paper 1059, 16 p.

Reed, W. E. and Lewis, J. E., 1978, Land use and land cover information and air-quality planning: U.S. Geological Survey Professional Paper 1099-B, 43 p.

Conservation Needs Inventory Committee of the U.S. Department of Agriculture, and Bureau of Indian Affairs, 1971, Basic Statistics--national inventory of soil and water conservation needs, 1967: U.S. Department of Agriculture Statistical Bulletin No. 461, 211 p.

The Committee for the World Atlas of Agriculture, eds., World atlas of agriculture, 4 volumes, Novara, Istituto Geografico De Agostini, 527 p.

Topography

Clarke, P. F., Hodgson, H. E., and North G. W., 1978, A Guide to obtaining information from the USGS 1978: U.S. Geological Survey Circular 777, 36 p.

National Cartographic Information Center, 1978, Digital terrain tapes, user guide (2d ed.): U.S. Geological Survey, 12 p.

Crop Acreages, Yields, and Prices

Statistical Reporting Service, 1975, Scope and methods of the Statistical Reporting Service: U.S. Department of Agriculture, Miscellaneous Publication no. 1308.

Population

U.S. Bureau of Census, 1978, Mapping for censuses and surveys: U.S. Department of Commerce Statistical Training Document ISP-TR-3, 353 p.

APPENDIX A

Some factors affecting machine processing of LANDSAT data for thematic classification of land use/land cover types:

- The Classification Scheme Itself: To date most land use/land cover applications have made use of previously defined schemes with, in limited instances some adaptation to remote sensing capabilities (U.S. Government, 1965). A land use/land cover classification scheme specifically designed with remote sensing in mind has been proposed by Anderson (Anderson et al., 1976).
- Feature Development and Selection: Spectral and spatial features are the primary inputs of remote sensor systems into the classification process. Attributes of significance include spectral, spatial, temporal, and quantization resolutions. To date most work has made exclusive use of spectral features, with limited but growing interest in spatial features such as texture and spectral transformations. With more (and better selected) spectral bands and spectrally derived features it will be necessary to reduce the overall dimensionality of data sets through various transformations. In many instances the temporal dimension is required for accurate discriminations; the addition of multiple dates to the analysis brings added emphasis upon the need for transformations which reduce dimensionality.
- Preprocessing Functions: Several radiometric and geometric characteristics of remotely sensed data are usually corrected or standardized prior to classification analyses. Sun angle and haze correction are two preprocessing functions that can significantly aid classification performance. Image geometric fidelity, necessary for multirate/source data overlay, is of critical importance to assure that features are always assigned to the same spatial location. There have been a limited but revealing set of studies concerning the impact of image registration accuracy and its impact on classification performance. Since geometric transformations involve resampling there has been a great deal of debate, but with little study, concerning the ways in which various resampling algorithms (such as nearest neighbor, bilinear and cubic convolution) affect classification performance. In addition, several investigations have opted for rectified but non-rotated imagery to minimize both radiometric resampling errors and computational costs associated with rotation.

- Generation of Class Training Statistics: Nearly all classification techniques involve the development of class training statistics which act as prototypes for pattern recognition purposes. The training stage of classification is considered by many to be the single most important component affecting overall classified performance.

Several techniques have been developed for training site selection. Perhaps the most conventional training procedure in use at present involves interpreter selection of training areas representative of each class. The experience of many researchers, however, has demonstrated that such directed training can significantly bias results because the analyst typically selects only those areas where confident interpretations are possible. In order to redress this bias, both systematic and random sample techniques have been tested for training purposes with much improved results.

Clustering is an unsupervised approach that attempts to identify the natural spectral classes present in a scene. A problem with many early cluster programs was the limited number of pixels that could be processed and the large computational requirements in general. Several algorithms have been implemented for clustering and both procedural steps, such as manual "seeding" and computational efficiencies, such as "weighted clustering" (similar in effect as a table lookup within a classifier), have resulted in a greater efficiency and larger scene capacities.

Image stratification using either collateral data or an image itself have also been employed with some success for training site selection since these data can serve to localize training class signatures to those areas for which they apply. To date, most automated stratification procedures have not proved successful, but manually defined strata have demonstrated that performance can be substantially improved through stratification.

It has long been recognized that training class statistics should be as representative as possible of the entire area being processed. One measure of their representativeness is often noted in the difference between training and test site classification performances. Since test sites are labeled but not used in the training process, their classification performance is generally lower than training sites, but usually more representative of overall classification performance. The higher performance

of training sites suggests that if total image training (i.e., total ground truth) were possible, classification accuracies could be optimized. While seemingly redundant (why classify if you have a map?), this approach can be effectively adapted somewhat to capitalize upon previous land use maps to develop training class statistics. Since time periods can be selected during which only a small proportion of changes occur it becomes possible to generate statistics effectively using a nearly complete set of ground truth (changed pixels may be avoided while training).

- Classification: Several algorithms, ranging from simple parallel - to computationally complex quadratic equations have been implemented to process remote sensing data. Classification accuracies using these various algorithms have been compared in many instances. When considering the goal of high classification accuracy within land resources the computational costs associated with more complex algorithms appears warranted due to their generally better performance accuracy.

Although the assumptions of many of these classifiers appear worthy of further study it seems that greater attention is needed in the development of sequential classification procedures (e.g., tree structures) and algorithms that can effectively integrate multisensor data and incorporate collateral information. Since some collateral data are continuous (such as terrain elevation), it can be treated as a "pseudo-spectral" channel in the classifier. Other collateral data, such as soils, however, cannot be incorporated in this manner. One method currently being investigated is to develop individual class "a priori" values for each state of the discrete variable (in this case soil types) and modify the decision rule in a Bayesian optimal manner according to the "a priori's".

- Performance Evaluation: The criteria for performance evaluations are often minimal and haphazardly applied to classifications developed from remote sensing data. Most analysts have been satisfied with statements of training and/or test site classification accuracies. Classification contingency tables are also commonly employed, but additional criteria, perhaps related to classification confidence statistics, need to be developed and employed.

Techniques for map classification accuracy assessment have been documented by USGS. In addition to standard per pixel techniques for assessing map accuracy is the potential use of variable grid sizes that contain several pixels within each grid cell (e.g., the 10 or 40 acre grid cell sizes in common use). When per pixel land use/land cover data have been aggregated to larger grid sizes it will be necessary to apply accuracy assessment techniques that account for this transformation since apparent per pixel accuracy would otherwise appear significantly lower than is the real case.

Again, it should be remembered that once LANDSAT data have been classified they should be rectified, registered, and input into some type of georeferenced data base for most efficient use in detecting long-term changes in land use/land cover categories and interaction with other data sets used in climatic modeling.

APPENDIX B

SUMMARY OF RECOMMENDED DATA SETS

<u>TITLE</u>	<u>COVERAGE</u>	<u>SCALE</u>	<u>LAND USE AND LAND COVER</u>	<u>FORMAT</u>	<u>VALID TIME SPAN</u>	<u>CONTACT</u>
World Atlas of Agriculture (Land Use and Land Cover)	Global	1:2,500,000 and 1:5,000,000	Map	Map	From 1965 15-20 years	Prof. Carlos Vanzetti University of Padua Verona, Italy
Canada Land Inventory	Canada (densely settled part only)	1:50,000 and 1:250,000	Map and Digital (polygon)	Map and Digital (polygon)	From 1962 15-20 years	Land Use Monitoring Div. Lands Directorate Environment Canada Ottawa K1A0E7
Surface Cover Characteristics of Canada	Canada	100km x 100km Grid area basis	Digital	Digital	15-20 years	Glen Hartog ARQL, AES/DOE Downsview, Ontario
Canada Land-Use Information Map Series - North of 60°	Canada (north of 60°)	1:250,000	Map and Text	Map and Text	20-30 years	Kenneth Taylor Lands Directorate Environment Canada Ottawa K1A0E7
USGS Land Use and Land Cover Maps and Data	U.S.A.	1:250,000	Map and Digital (polygon)	Map and Digital (polygon)	From 1972-82 10-20 years	James R. Anderson Chief Geographer (710) U.S. Geological Survey Reston, Virginia 22092
1967 Conservation Needs Inventory	U.S.A. (non- federal land)	Data collected on basis of 2% stratified random sample	Tabular	Tabular	From 1967 10-20 years	Raymond I. Dideriksen Soil Conservation Service P.O. Box 2890 Washington, D.C. 20013

<u>TITLE</u>	<u>COVERAGE</u>	<u>SCALE</u>	<u>FORMAT</u>	<u>VALID TIME SPAN</u>	<u>CONTACT</u>
1974 Census of Agriculture	U.S.A. (land in farms only by counties)	Data collected by 100% enumeration of farmers	Tabular	Available every 5 years	Chief, Agriculture Div. Bureau of Census Washington, D.C. 20233
Major Uses of Land, 1974	U.S.A.	Data from Census of Agriculture and from other federal agencies on state basis only	Tabular	From 1974 10-15 years (available every 5 years)	H. Thomas Frey U.S. Department of Agriculture culture Economics, Statistics and Cooperatives Service 500 - 12th Street, SW Washington, D.C. 20013
<u>VEGETATION TYPES</u>					
Potential natural vegetation (Kuchler)	U.S.A.	1:3,168,000 1:7,500,000	Map	As of 1964-revised in 1970	National Atlas of U.S.A. U.S. Geological Survey Reston, Virginia 22092
International Classification and Mapping of Vegetation, (UNESCO)	Global	1:1,000,000 or less	Map	At time of observation	Kuchler, University of Kansas
USDA Forest Service Resource Evaluation Data	U.S.A.	N/A	Tabular	10-15 years	U.S. Forest Service, Forest Resources and Economics Research Washington, D.C. 20013
Forest Regions of Canada	Canada	1:5,000,000	Map	As of 1972	Rowe, University of Saskatoon
Biomass by Canadian Forest Regions	Canada	N/A	Tabular	1979	Forest Management Inst. Canadian Forest Service

<u>TITLE</u>	<u>SOILS</u>			<u>VALID TIME SPAN</u>	<u>CONTACT</u>
	<u>COVERAGE</u>	<u>SCALE</u>	<u>FORMAT</u>		
Canadian Soil - Climate data base	Canada	1:5,000,000	Digital	30 years	Julian Dumanski Soil Research Institute Ottawa, Canada 613/995-2373
Canadian Land Data System	Canada (south 60ON)	1:250,000 1:50,000	Map and Digital	30 years	M.E. Beaudette Land Management Infor- mation Systems Lands Directorate Environment Canada Ottawa K1A0E7 997-2510
Soil Survey Maps and Data	U.S.A.	1:15,840 to 1:24,000	Map and Tabular	30 years	R. B. Daniels Soil Conservation Ser. P. O. Box 2890 Washington, D. C. 20022 202-447-4991
Soil Moisture & Satellite Data	World	?	Digital	1 month	R. Jenne
Digitized Soil Map 50 x 50km	World	?	?	30 years	R. Jenne
Daily Soil Temperature Data	Canada - 67 stations	Points	Tabular	30 years	?
FAO Soil Map of the World	World	1:5,000,000	Map	30 years	R. B. Daniels U.S. Soil Conservation Service P. O. Box 2890 Washington, D. C. 20013

<u>TITLE</u>	<u>COVERAGE</u>	<u>SCALE</u>	<u>FORMAT</u>	<u>VALID TIME SPAN</u>	<u>CONTACT</u>
Soil Pedon Data	U.S.A.	N/A	Tabular & Partially Digital	40 years	C. S. Holzhey, Head National Soil Survey Lab. U. S. Soil Conservation Ser Lincoln, Nebraska 68508
Soil Interpretation Record	U.S.A.	N/A	Tabular & Digital	40 years	Keith Young U.S. Soil Conservation Ser. P. O. Box 2890 Washington, D. C. 20013
Canada Soil Information System (CANSAS)	Canada	1:125,000 to 1:5,000,000	Digital	30 years	Julian Dumanski Soil Research Institute Ottawa, Canada 613-995-2373

TOPOGRAPHY

USGS Topographic Base Maps	U.S.A.	1:100,000	Map	10 years	National Cartographic Information Center, USGS U.S. Geological Survey Reston, Virginia 22092
USGS & DMA Topographic Base Maps	U.S.A. & parts of the world	1:250,000	Map	20 years	"
USGS Digital Terrain Tapes	U.S.A.	1:250,000	Digital	20 years	"
USGS Topographic Base Maps	U.S.A.	1:24,000	Map & some digital	10 years	"
DMA Small Scale Maps	World	1:1,000,000 to 1:5,000,000	Map	20 years	Defense Mapping Agency Topographic Center, Code 55200 Washington, D. C. 20315

<u>TITLE</u>	<u>COVERAGE</u>	<u>SCALE</u>	<u>FORMAT</u>	<u>VALID TIME SPAN</u>	<u>CONTACT</u>
	<u>CROP ACREAGES, YIELDS, AND PRICES</u>				
USDA Foreign Crop Estimates	Global	Country	Digital Tabular	Historical, updated monthly	Director, Data Systems Division Foreign Agricultural Service U.S. Department of Agriculture Washington, D. C. 20250 202-447-5255
USDA Official USA Estimates	U.S.A.	State, County	Digital Tabular	Historical, updated monthly	Data Services Branch Survey Division Economics, Statistics, and Cooperatives Ser. U.S. Department of Agriculture Washington, D. C. 20250 202-447-7017
CANSIM (Canadian Socio-Economic Information Management	Canada	Province	Digital	Historical, up to date	User Advisory Services Division, Statistics Canada 25 St. Clair Avenue, East Toronto, Ontario CANADA M4T 1M4 966-6574
	<u>REMOTE SENSING DATA</u>				
LANDSAT (USA)	U.S.A.	1:1,000,000, but can go to 1:250,000 and still meet U.S. National map accuracy standard in specific cases	Digital & Analog	10-20 years for generalized land cover	User Services Division U.S. Geological Survey EROS Data Center Sioux Falls, South Dakota 57198

<u>TITLE</u>	<u>COVERAGE</u>	<u>SCALE</u>	<u>FORMAT</u>	<u>VALID TIME SPAN</u>	<u>CONTACT</u>
LANDSAT (Global)	Nearly Global- 850N-850S, About 85% of the earth's land sur- face has been covered since 1972	1:1,000,000 but can go to 1:250,000 and still meet U.S. National map accuracy stand- ard in specific cases	Digital & Analog	10-20 years for general- ized land cover for climatic models	User Services Division U.S. Geological Survey EROS Data Center Sioux Falls, South Dakota 57198
Heat Capacity Mapping Radiometer on Applications Explorer Mission-1	Potential for nearly global coverage 850N-850S limited coverage to date	1:5,000,000 to approx. 1:1,000,000	Digital & Analog	Data on thermal inertia & heat islands effects may have long- standing validity	Dr. John Price HCM Project Scientist NASA Goddard Space Flight Center Greenbelt, Md. 20771

CLIMATE INVENTORY

Working Group 7

Chairman: Kenneth Hadeen

Members: Carmen Benkovitz
Bernard C. Diesen
David Drury
David Durica
Douglas Edwards
J. Patrick Gary
Eugene Hoppe
William Klint
Christopher Noe
Douglas Troop

SUMMARY

The Climate Inventory Working Group reviewed requirements for data inventory and data information, reviewed some existing data inventory/information systems, reviewed existing technology, and developed a feasible approach to meet known user requirements.

The Climate Inventory Working Group recommends that the National Climate Program Office take active responsibility for coordination and implementation of a climate data inventory/information program to:

- Establish a core implementation team.
- Allocate appropriate dedicated resources for the development of the program.
- Include interagency participation in a steering group capacity.

Working Group 7 identified 10 major tasks that must be addressed to fulfill the above recommendations.

In reviewing pertinent sections of the draft 5-year plan of the National Climate Program Office, Working Group 7 recommends

that the Plan be strengthened in the data management and information services section. The following recommendations are made:

- Existing resources be utilized during the remainder of fiscal year 1979 and fiscal year 1980 to develop a management implementation plan for the organizational structure and inventory service activities.
- Dedicated resources be made available in fiscal year 1981 for initial implementation activities with a full implementation of the program within the 5-year time frame.
- An interagency steering group should be established at the earliest possible date to guide, review, and advise a small, fully dedicated core implementation team charged with the responsibility for developing the implementation plan and specifications for required resources.

BACKGROUND

Inventory systems have undergone considerable change in the last decade to meet the requirements brought about by an ever increasing volume of data, types of data, and user demand for data. Automated systems have evolved - sometimes haphazardly as a way to get the job done. Initial inventories were oriented toward single files, or even frequently used subsets of single files, were fragmented, were updated randomly, and had differing levels of information. Historically, these inventories were created in response to user demands for data from individual agencies.

Only in the last 10 years have serious efforts been made to design higher level, user-oriented inventory systems. The explosive growth of users' demands for accurate, timely information has followed the great advances in hardware technology and software design.

Today there exist a limited number of sophisticated data inventory/information systems. The creators of these systems found it necessary to combine like data inventories, in differing forms and stages of completion, from many agencies involved in similar data collection/processing efforts. With these various agencies cooperating in the design and development of these high level inventory/information systems, and using their many existing individual inventories, they implemented a unified inventory

system from which multi-disciplined information is now available. Some examples of such systems are National Water Data Exchange (NAWDEX), Remote Control Bibliographic Data Service (RECON), Environmental Data Index (ENDEX), Ohio College Library Center (OCLC), etc. These are not the only high-level systems in existence but are presented as representative of usable inventory systems.

There are many other high-level inventory systems, that have the same or even greater scope and magnitude, in the planning/development stages. An example of such a system is the present Environmental Data and Information Service (EDIS) effort to combine its five centers' data collection/processing/archival resources to produce a single Data Dictionary/Directory system. This system will contain data inventories, software inventories, definitions of software variables, abstracts, history, and location/media information. Other examples include similar efforts by the U.S. Department of Agriculture (USDA), National Aeronautics and Space Administration (NASA), State governments, and others.

On the international scene, most major international organizations, World Meteorological Organization (WMO), Intergovernmental Oceanographic Commission (IOC), Food and Agriculture Organization (FAO), United Nations Environment Program (UNEP), etc., concerned with climate or climate-related data have or are planning data surveys and inventories. These are at various stages of development and contain varying levels of detail and scope of coverage. In addition to existing agency contacts, access to and interaction with these organizations will be important, if not mandatory, in developing information on global data sources.

TECHNOLOGY CONSIDERATIONS

Any recommendations for implementation of an inventory system of climatic information must logically consider the current technology available to support such a system.

Computer Hardware

During the past two decades, there has been a dramatic decrease in the costs associated with computer hardware. At the same time, there has been a substantial increase in the processing power of computer systems for each dollar invested.

The advent of the personal computer market makes possible access to digital systems by unsophisticated users for under \$3,000. This places on-line capability (including hardcopy output) in the hands of consulting meteorologists, local agencies, and others.

Computer Software

Computer software technology has also made great strides over the past decade. These improvements include more efficient operating systems and more powerful basic-level and higher-level programming languages. In addition, software to support interactive processing, on-line program development and data entry, and sophisticated telecommunications permit the user maximum flexibility.

One of the more recent significant developments in data processing are Data Base Management Systems (DBMS). These software systems have proliferated over the past several years to meet the more complex information handling requirements of the user. Typically with the development of computer systems, the early DBMS's were not very cost effective, nor did they always satisfy the wide spectrum of demands placed on them. Today, these less efficient systems are giving way to more sophisticated systems which provide the user greater flexibility, and provide lower computer operating costs for a relatively low capital investment.

Computerized Reference Services

Computerized reference services are another resource to an automated inventory of climatic information. These systems provide access to information about data being collected, data available at a particular location on a particular subject, or abstracts and bibliographic reference data on published reports. Such a service is provided by the Department of Agriculture's Current Research Information System (CRIS). CRIS provides brief abstracts on research in progress within the Department or at various institutions being funded by the Department. The system is resident on the Lockheed Electronics Company DIALOG system. Retrieval requests can be submitted via the USDA or, if the user has an account with Lockheed, directly via a computer terminal.

Telecommunications

Developments in digital telecommunications continue to reduce costs and improve the accuracy and speed of transmission for large volumes of data. Leased telecommunication services through the various communication companies have expanded in recent years. These services range from low-speed dial up circuits to very high speed, high-volume satellite communications links between major cities.

Mass Storage Systems

Mass Storage Systems (MSS) of today allow quasi-on-line storage of massive amounts of data at relatively low cost and with a much improved retrieval rate over conventional magnetic tape storage. Several such systems are presently available and others are currently being developed.

USER REQUIREMENTS

Based on workshop comments and the experience of various data centers, consideration must be given to the variety (multi-disciplines) of users and the attendant multiple data sources in order to satisfy the users' requirements.

The assessment of user requirements for data and information is an important consideration in the design of an inventory/information system. Due to the highly variable nature of user requirements, the system must be designed to meet a continually changing community of users and their demands. Some of these demands include:

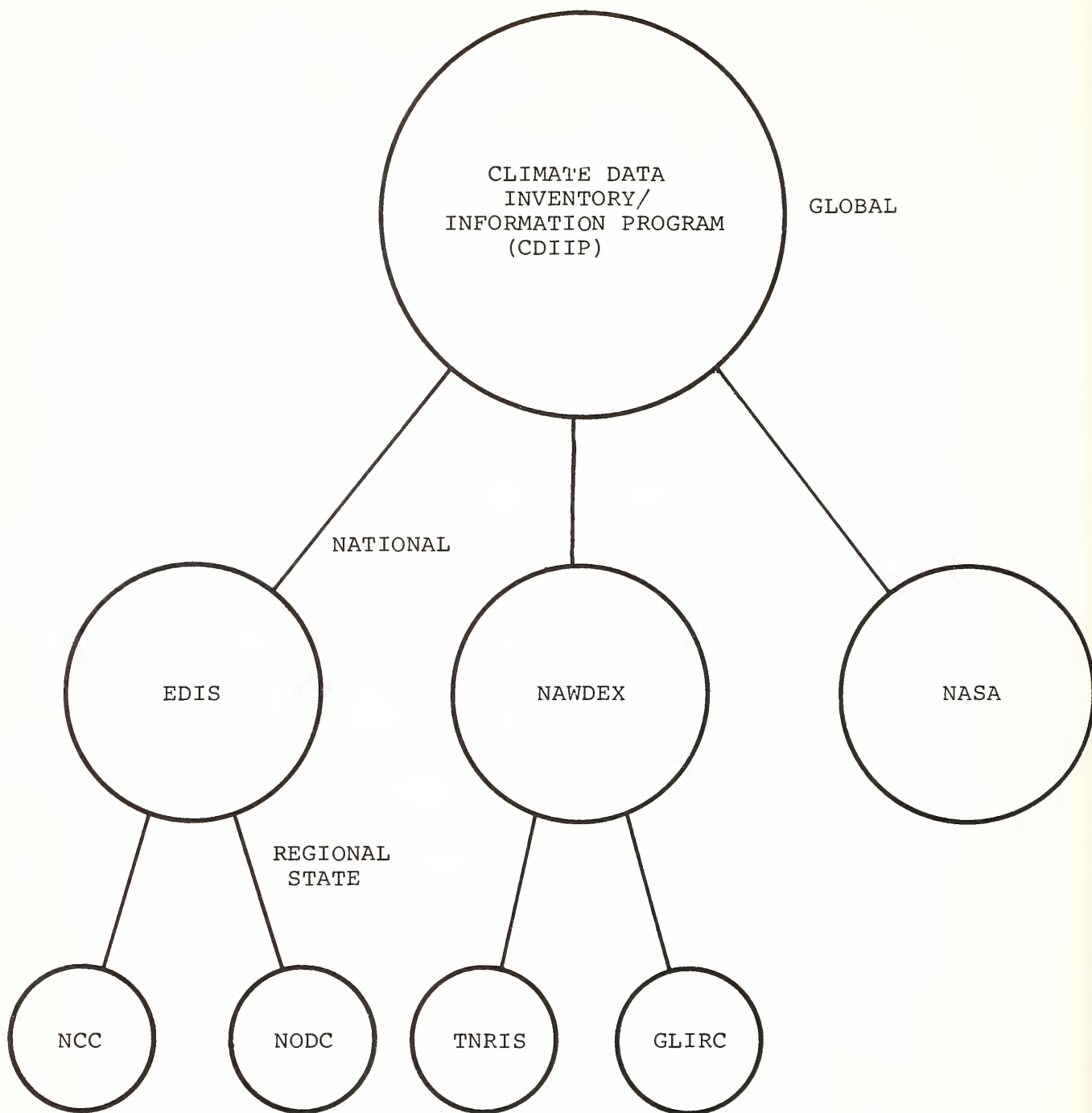
- Data description
 - Parameters available
 - Time/space description
 - Indication of data quality
- Indications of available formats
- Rapid response to inventory requests

PROGRAM CONCEPTS

The climate data inventory/information program should consist of a centralized facility with the mission of identifying and improving access to existing climatic data resources. It should have the responsibility for:

- Coordinating and fostering maximum use of existing climate-related inventory and service systems.
- Developing additional inventories and systems necessary to describe and index new and additional climate data.

INVENTORY PROGRAM CONCEPT



- Developing a viable program of user services to provide access to its own and participating data and information resources.

A structured or hierarchical data information system (not necessarily digital) complementary to the level of information needed would best suit these needs. A hierarchical structure with each level increasing in data information content is conceptualized (see figure). The inventory/information program would, in a broad way, point the user to the source of the particular data that relates to the user needs. It would be an "inventory of inventories." Once the what, where, and how has been established relative to particular needs, the user might then elect to access the next level of information. This lower level would describe specific data related to the user needs. Ever increasing detail could then be called to the point of ordering the data or products from the data source.

RECOMMENDATIONS

A. Climate Inventory Working Group Recommendations

The Climate Inventory Working Groups recommend that the National Climate Program Office take active responsibility for coordination and implementation of a climate data inventory/information program to:

- Establish a core implementation team.
- Allocate appropriate dedicated resources to the development of the program.
- Include interagency participation in a steering group capacity.

In order to accomplish the above recommendations, the following tasks must be addressed.

1. Encourage (possibly mandate) individual Federal agencies to conduct and maintain detailed survey/compilations of their climate data holdings. (Circular A-62, 1963)

In the current scenario of multiplicity of data sources and usage, accurate, up-to-date inventories of a Federal agency's data holdings become indispensable to the efficient management of such data. In order to make a national climate

data inventory/information program feasible, these individual agency inventories become imperative in the area of climate related data (USGS 1976). The NCPO should ensure that all participating Federal agencies are aware of the needs of the Climate Plan in this inventory area and should encourage such inventories when needed.

2. Conduct a survey of non-Federal agency data producers/managers to identify their climate related data holdings.

Not all climate related data holdings reside within the domain of Federal agencies. In order to ensure completeness, the climate data inventory/information program must include these non-Federal holdings. The NCPO should assume responsibility to ensure that a survey of these climate data is accomplished and maintained, and that information on this survey is available as part of the data inventory/information program.

3. Develop a categorized but detailed list of user requirements for different levels/capabilities of climate data inventory.

User requirements are expected to be greater than the capabilities of existing inventory systems. An exhaustive listing of existing user requirements will provide a baseline for the climate data inventory/information program. Existing user requirements, when compared with the current capabilities of existing inventory systems, will indicate the magnitude of additional resources necessary.

4. Conduct a detailed comparative study of the capabilities of existing inventory systems.

In order to create an adequate inventory system, it will be necessary to conduct such a study. The study will provide the basic information required to assess the capacity and unique handling requirements associated with climatic information.

5. Conduct a design analysis to identify and evaluate a number of inventory alternatives.

This recommendation addresses the need to evaluate alternative approaches to establishing an inventory system. The

advantages of a centralized versus a decentralized computer system must be considered. The methodology for capturing inventory information from a variety of diverse organizations must also be considered in recommending the desired approach.

6. Develop an implementation plan for the phased development of a national climate data inventory suitable for meeting climate data user requirements.

With the results of the previous analyses, the NCPO should require that the core implementation team develop a reviewable document describing the method for developing the required national climate data inventory. This document should include a description of milestones commitments of funding and people resources, and assignments of implementation-related managerial responsibilities. This document would serve as an implementation plan to guide actual implementation activities.

7. Develop proper feedback mechanisms to increase user involvement both in the development of the evolving climate data inventory/information program and in identifying other climate data management areas needing further attention.

Increased user involvement during each phase of planned implementation must be encouraged through responsive feedback mechanisms to allow the data inventory/information program to evolve to satisfy the user community needs. Other candidates for climate data management may be identified for inclusion into the inventory program. Some of these may include inventories of derived products, climate related models, etc.

8. Implement the inventory and develop procedures for continued maintenance.

Implementation of the plan developed under recommendation 6 should begin as soon as possible. The value of an inventory system is directly proportional to how up-to-date it is. Therefore, guidelines and procedures should be developed for the continued maintenance of the inventory. The NCPO should ensure that these procedures are implemented.

9. Devise a mechanism to increase public awareness of the existence of, and the services provided by, the climate data and inventory/information program.

Users and potential users of the inventory must be made aware of the capabilities and services available through the inventory program. An educational process must also be established to interested users in the use of services and product. This will include improving the awareness of all other systems and services participating in the program.

10. The Climate Data Inventory Program should, when operational, provide a service to answer queries from users who do not have access to a remote terminal.

This could be accomplished by:

- Periodically publishing a catalog of the inventory.
- Establishing an operational office or delegate to a line organization the responsibility to answer users' queries via commercial communication lines to an extent that this service cannot be met by existing archive centers.

B. National Climate Program Five-Year Plan Recommendation

The previous recommendations of the Inventory Working Group respond to the requirements of the 5-year plan of the National Climate Program, Section IIC on Climate Data, Information, and Services. The plan recognizes the need that climate data users must know which data exist and how they can be obtained. The plan specifically addresses the goal of the climate information services component to establish an active program to facilitate the use of climate and climate-related information for improved planning, policy-making, natural resources, management, design, and operation in both the public and private sector of our national activities. In support of the plan, the Inventory working group gave careful consideration to the need for flexibility to improve public awareness, and to inventory a wide diversity of climate observations made in support of a wide array of data-collection programs active in a multi-disciplinary program, multiagency environment; accounting for the diagnosis and projection capabilities of inventories sources; maximum utilization of, and close coordination with, existing inventory and data systems in climate-related programs; and designed flexibility to respond to the changing needs of a diverse and changing user community.

It is therefore recommended that the 5-year plan be strengthened to display a more assertive program of response to the stated needs relating to data management and information services. It is recommended that:

- Existing resources be utilized during the remainder of fiscal year 1979 and fiscal year 1980 to develop a management implementation plan for the organizational structure and inventory service activities.
- Dedicated resources be made available in fiscal year 1981 for initial implementation activities with a nearly full implementation of the program within the 5-year frame.
- An interagency steering group should be established at the earliest possible date to guide, review, and advise a small, fully dedicated core implementation team charged with the responsibility for developing the implementation plan and specifications for required resources.

CLIMATE INVENTORY ACRONYMS

<u>AGENCIES</u>	<u>SOFTWARE SYSTEMS</u>	<u>ACRONYM LIST</u>
A		NAWDEX - National Water Data Exchange
	S	RECON - Remote Control Bibliographic Data Service
	S	ENDEX - Environmental Data Index
	S	OCLC - Ohio College Library Center
A		USDA - U. S. Department of Agriculture
A		NASA - National Aeronautics and Space Administration
A		EDIS - Environmental Data and Information Service
	S	CRIS - Current Research Information System
	S	DIALOG - Lockheed's software package
A		NCPO - National Climate Program Office
A		WMO - World Meteorological Organization
A		FAO - Food and Agriculture Organization
A		IOC - Intergovernmental Oceanographic Commission
A		UNEP - United Nations Environment Program
	S	TNRIS - Texas Natural Resources Information System
A		GLIRC - Great Lakes Information Referral Center

REFERENCES

Circular A-62, 1963. Policies and procedures for the coordination of federal meteorological services, Office of Management and Budget, 4 p.

Report 1976. Development of a catalog of information on surface meteorological data, U.S. Geological Survey, Office of Water Data Coordination, Interagency Advisory Committee on Water Data, 65 p.

II. SPECIAL TOPICS

OPEN LETTER TO THE U.S. DEPARTMENT OF AGRICULTURE

Kenneth D. Hadeen, Acting Director
Center for Environmental Assessment Services
National Oceanic and Atmospheric Administration



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Rockville, Md. 20852

June 13, 1979

Dr. Galen Hart of the U.S. Department of Agriculture (USDA) asked the National Climate Program (NCP) Data Management Workshop to provide guidance on how the USDA data cataloging and indexing system should be designed to be most compatible with relevant data bases elsewhere. It was not possible, within the context of the Workshop, to address specific agency institutional requirements for cataloging and inventory design criteria. However, there exist several review studies of the configuration and status of major existing inventory/information systems in the U.S. No comprehensive or cohesive study has been made to date which would serve as the basis for the design of a compatible agency system. USDA and other agencies contemplating development of such a system should coordinate their development plan and design criteria with their major data interfaces (suppliers and archives) in cooperation with the NCPO Data Management Staff and advisory of Climate Data Inventory groups designated by that office.

Experience gained through the Workshop data survey and background developed by Working Group 7 members indicates that there is overall similarity of information content between existing inventories. At a given inventory level, disciplines or agency standards (where such exist), specific special area requirements and mode of development have resulted in a multiplicity of formats, nomenclatures and codes. These differences can present serious difficulties in deriving compatible information from many systems for multidiscipline climate program uses. When developing new systems, we strongly urge that agencies coordinate their design specifications with existing interdisciplinary systems such as the

National Water Data Exchange (NAWDEx) to gain compatibility among codes and nomenclatures.

Regarding cataloguing and retrieval systems: NASA and the Department of Energy both use the REMOTE CONSOLE Bibliographic Information System (RECON). In addition, the CIA is also considering RECON. There may be some advantage to USDA adopting a system which is in the public domain and with which other agencies have had long experience. Mr. Van Wente of NASA's Scientific and Technical Information Office can provide detailed information on RECON. That system, and variants marketed by Lockheed Corporation are not unique. Other systems (e.g., at Department of Justice and National Library of Medicine) accomplish similar tasks.

There are many avenues available to meet USDA requirements. We hope that whatever actions the agency takes will be coordinated with existing data bases elsewhere and with those having important needs for USDA data.



OPEN LETTER TO THE DEPARTMENT OF DEFENSE

Roy L. Jenne, Manager
Data Management Activities
National Climate Program Office



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Rockville, Md. 20852

Lt. Col. E. W. Friday raised the question: how should DoD climate data and analyses be made more readily available to potential users in the civil sector. DoD data are, of course, collected and analyzed to meet requirements of the various services. However, those data can be of value more broadly, so methods have been set up to make those data available to the public. Often, the problem is on the user side of the interface. The user needs to know how to access the data for DoD facilities often do not deal directly with general civil sector users. The problem then is one of publicizing the sources of DoD data and analyses. Here is a listing of DoD data sources.

Basic Atmospheric Data

Conventional data are prepared for global military and civilian stations by USAF-ETAC and by Navy-FNWF (Monterey). Satellite IR sounding data are prepared from Defense Meteorological Satellites Platforms (DMSP).

The USAF and Navy data primarily are available through NCC and some through NCAR and NORPAX administrative office at Scripps Institute of Oceanography. Some Navy data is only available at Monterey, but arrangements may be made to store additional Navy data files at NCC, if necessary.

Precipitation, Hydrologic, Snow and Ice Data

Precipitation (rain and snow) is available in the USAF weather data file and can be obtained through NCC. The Navy unit at Suitland prepares and publishes ice largely from satellite data.

The Army Corps of Engineers gathers some data on river stages, river discharge, and water quality. Data gathered for short periods don't get into the USGS files; they remain with the 37 Army Corps Districts. There may even be some long-term observing sites that aren't available through USGS. This is now being resolved.

The Army Corps of Engineer's Cold Regions Research and Engineering Laboratory (CRREL) has prepared ice and snow data and compiled bibliographies. Selections of the data will soon be available through EDIS/WDC-A for Ice and Snow in Boulder, Colorado.

Oceanographic Data

The Navy and Air Force each decode and archive data from the global military and civilian surface ships. These data are available through NCC or NORPAX.

The Navy decodes XBT data which are available through NODC.

Radiation, Physics, Chemistry

Data are collected by the DMSP satellites.

The IR soundings are stored at NCC. Data for parameters such as protons are saved at EDIS/NGSDC in Boulder. The DMSP satellite ozone data are processed at the Satellite Ozone Analysis Center (SOAC) at Lawrence Livermore Laboratories.

Satellite Imagery Data

The DMSP images along satellite swaths are archived at the University of Wisconsin. The rectified polar images (composites from different swaths placed on standard map projections) are archived at WDC-A (Ice and Snow) in Boulder, Colorado. The maps for tropical areas will probably be kept at Colorado State University, Department of Meteorology.

The satellite pictures are on film which can be borrowed, but not copied.



DISPOSITION OF DATA INVENTORY INFORMATION

Dudley G. McConnell, Acting Associate Director
Information Services
National Climate Program Office



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Rockville, Md. 20852

In preparation for the Workshop, the Working Group Chairmen sought to compile inventories for their data regimes. This was done by circulating Data Set Information Sheets (i.e., data sheets) to data repositories and data managers. The format for the data sheets was developed by the Climate Program Office; mailings were made by the Chairmen and Working Group Members; responses were received, logged, and tabulated by NOAA/CEAS (Mr. David Drury). The table below summarizes the responses.

The completeness of the responses varied over a wide range. So it is necessary to review the data sheets in detail, amend those sheets which are incomplete, and apply uniform criteria in assessing the data sets. It was originally hoped that much of this could be achieved at the Workshop; however, there was insufficient time. Nevertheless, we should not squander all of the effort expended in collecting the data sheets. Therefore, the National Climate Program Office and NOAA/CEAS will work together to see that the collection of data sheets is finally published. There are funds in the NOAA FY80 budget to start work on an inventory project. The Workshop agreed that publication of this collection of data sheets would be a useful step toward a comprehensive inventory.



NDP DATA MANAGEMENT WORKSHOP
DATA SET SURVEY
SURVEY SOURCE LIST

June 6, 1979

L. David Drury
NOAA/EDIS/CEAS

<u>SURVEY SOURCE</u>	<u>ENTRIES</u>
AES/LOG (07-04)	44
AES/MCKAY	1
AES/SURVEY	249
BENKOVITZ	1
DARLING	17
DOD/OCEAN	62
DOD/SURVEY	109
GMCC	13
JENNE	203
KLINT	1
NASA	1
NCC/EDIS	22
NCC/SDSD	16
NOAA	1
NORPAX	41
TROOP	1
WDC-A/GLACIOLOGY	42
WG1	9
WG2	14
WG3	27
WE4	10
WG5	2
WG6	27
<hr/>	
TOTAL ENTRIES	918
<hr/>	

SUMMARY BY GROUP

<u>GROUP</u>	<u>NUMBER</u>
1	278
2	150
3	197
4	174
5	25
6	64
7	32



19 April 1979

Dr. Roy L. Jenne
National Climate Program Office
U.S. Dept. of Commerce
NOAA
Rockville, Maryland 20852

Dear Roy,

I'm sorry I can't attend the meeting on the Climate Data Base. I would like, however, to make a few comments regarding this most important aspect of the overall research strategy.

My own involvement in efforts to define data base requirements started with the international GARP climate conference held in Stockholm in 1974--published in GARP 16. That report attempted to estimate the scope and accuracy of climate data sets for research purposes. Many of these estimates have since been modified, but it remains important to produce an initial data set and a plan for improving it.

I think that the experience of NCAR is worth recalling. The NCAR effort to gather together certain atmospheric data sets and make them available in compact form has provided a tremendous stimulus to studies of the general circulation and interannual variability.

The draft report of the JOC Climate Board's Working Group on Data for Climate Research (1976-1977) represents in my estimation the best guidelines on how to proceed. As you know, the report of the Climate Dynamics Panel to the US Committee for the GARP (Elements of the Research Strategy for the US Climate Program) noted that the JOC report could be used as a basis for further development of data base plans.

I've attached a few sheets extracted from "Elements" that suggest broad guidelines. It is my judgement that both "basic" and "applied" research would benefit greatly from easier access to atmospheric, oceanic and hydrologic data sets. If I can answer more specific questions, please call.

Sincerely,

/s/ John

John E. Kutzbach, Professor
Department of Meteorology
Director, CCR

JEK:mw

Enclosures:

- a) Elements - Recs. 1,2
- b) Elements - Sec. 3.2.1
- Elements - Sec. 4.1

INSTITUTE FOR ENVIRONMENTAL STUDIES

NOTE: Extracted from "ELEMENTS."

" RESEARCH STRATEGY FOR THE UNITED STATES CLIMATE PROGRAM

Fulfillment of objectives 2 and 3 will depend to a certain extent on progress toward objective 1. However, knowledge of how the climate system operates can be very useful in sensitivity and predictability studies and need not require a complete understanding of the system. Thus, research in these three areas can proceed in parallel.

The research strategy for the climate program builds from a base of considerable knowledge, summarized briefly in Chapter 2. The degree to which climate is predictable is not yet known, nor can the degree to which climate is sensitive to man-made changes be assessed. However, there is sufficient information to define the elements of an expanded research program that will address these questions.

Two lines of research activities are anticipated: (1) efforts of individual scientists covering a range of theoretical and empirical studies and, concurrently, (2) joint efforts of many scientists concentrating on the following four major tasks:

1. Development and maintenance of an accessible data base.
2. Development and maintenance of an observing/monitoring system.
3. Development and conduct of climate process experiments.
4. Development of climate models.

Chapter 3 provides a long-term strategy for these four major activities. Chapter 4 provides a detailed listing of major activities to be continued or initiated during the five-year period from 1978 to 1983. It concludes with a discussion of how these activities should contribute to the program objectives in climate diagnosis, climate sensitivity, and climate predictability.

1.2 PRINCIPAL RECOMMENDATIONS

The principal recommendations are as follows:

1. It is recommended that the instrumental record climate data base be properly assembled, checked, synthesized, and made easily accessible to scientists engaged in climate research (see Sections 3.2.1 and 4.1). Many of the data sets needed for climate research will also provide information for users. Therefore, efforts invested in this area should yield immediate and long-term benefits.

2. It is recommended that the noninstrumental record climate data base be further developed (see Sections 3.2.1 and 4.1). The instrumental record is relatively short and geographically incomplete. Heavy reliance must be placed on the analysis of noninstrumental records to determine patterns and processes of natural climate variation at time scales longer than a decade.".....

(General Climate Research Strategy (Long Term))

"3.2 STRATEGY FOR FOCUSED EFFORTS

The strategy for focused work in the four areas mentioned in Section 3.1 is based on our present level of understanding and the present state of the data base and the observing/monitoring system. These, to a large extent, will dictate the timetable for achieving various objectives.

The following items will be elaborated in Chapter 4.

3.2.1 Climate Data Base

Observations are fundamental to the study of climate. Most of the advances in our knowledge and understanding of the atmosphere and the ocean have been based on observations. Improvement of the present instrumental record data base is possible in the next few years and is, therefore, a high priority for immediate attention. Many of the data sets needed for climate research will also provide climate information for user applications. Therefore, efforts invested in this area should yield immediate as well as long-term benefits.

The length of instrumental records (on the order of 100 years) limits studies of climate variation to time scales up to the order of decades. Furthermore, the instrumental records are not necessarily representative of other climate regimes (glacial, as an extreme example) and may not be of sufficient length or spatial coverage to reflect extreme events adequately. Efforts must be made to develop a noninstrumental record data base. Significant improvement in this data base can be expected in the next few years. However, a long-term effort will also be required to realize the full potential of past climate studies.".....

NOTE: Extracted from "ELEMENTS."

"4

SPECIFIC RESEARCH NEEDS FOR THE
NEXT FIVE YEARS (1978-1983)

Within the framework of the long-term research strategy described in Chapter 3, an outline is now given of many of the specific research needs for the next five years (1978-1983). This refers only to large, collaborative efforts involving the development of the climate data base, the climate observing/monitoring system, the process/regional experiment, and the climate modeling capability and does not mention the broad range of research projects that need to be undertaken by individual scientists.

4.1 DEVELOPMENT OF A CLIMATE DATA BASE

4.1.1 Development of a Climate Data Base from Existing Instrumental Records

The development of climate data sets from existing instrumental records is an important immediate task. A major effort is required to assemble the data, assess data quality, and make the data sets readily available in appropriate form to scientists. For certain purposes, it will also be important to synthesize the data from different sensing systems (space, land, and ocean based and airborne) into a consistent and optimal form.

First, many of the data are not available on magnetic tape or similar storage. Quality control is important yet sometimes absent or inadequate. Second, the data sets often have not been gathered together and structured for easy use. For example, an early 12-year set of all U.S. rawinsonde observations was scattered across several hundred tapes. The National Climatic Center has recently gathered these data into logical order on about 50 tapes. The cost of gathering and preparing data is usually high compared with the cost of exchanging it. Thus, a tape costing \$15 can hold the equivalent of 200,000 to 500,000 punched cards, while the keypunching of 500,000 cards may have cost \$75,000. A climate study of the southern hemisphere required several man-years and about \$300,000 to prepare and publish, yet the digital values are now contained on a portion of one magnetic tape.

Over the past several years, the National Center for Atmospheric Research (NCAR) has assembled, checked, and compacted a variety of climate data sets. These are now available on magnetic tape to the research community. Although these data sets are only a first step toward development of a comprehensive climate data base, they have been most useful and form a point of departure for further development. The inclusion of more climate variables,

continued work on data quality control, and extension of the data set in terms of global coverage and record are now needed.

In summary, data may be available in principle; in actuality, data are often not available for easy use and exchange. The main priority, therefore, should be to obtain or create the various basic data sets. The Report of the JOC Ad Hoc Working Group on the Global Data Base for Climate Research (GARP, 1976b) can be used as a basis for further development. Three subtasks can be identified as follows:

1. Assemble "1950-present" data set. This set would include most of the observations of three-dimensional atmospheric structure from the radiosonde network as well as more recent satellite-based observations (target date for completion: 1983).

2. Assemble "long-term instrumental record" data set. In selected locations, instrumental records from the atmosphere, ocean, and land surface go back to the 1800's and, in a few cases, the 1700's. While not global, these records are valuable for estimating time and space scales of natural variability and for exploratory studies of processes (target date for completion: 1983).

3. Assemble "compressed" FGGE data set. The FGGE data set will provide the most detailed picture to date of one annual cycle. The above-mentioned JOC document defines the content of the compressed set as consisting of the time- and space-averaged statistical properties of all the FGGE data sets (target date for completion: 1980-1981).

A working-level group (or groups) should be constituted as soon, as possible to advise the government on priorities for specific tasks within these three categories. Certain data sets can serve both research needs and the needs of users of climate information. It is, therefore, important to be aware of the needs of both research and user communities in order to optimize the data processing.

4.1.2 Applications of Technology to More Efficient Acquisition, Processing, and Retrieval of Present and Future Climate Data

There is an immediate need to apply available technology to problems of data acquisition, processing, and retrieval. The tremendous volume of data for climate research is currently overwhelming the data system. For example, certain meteorological satellite signals are not being routinely processed or stored, and large numbers of bathythermograph recordings have never been processed. Without significant improvements in the data-management area, the increased data flow will not be handled properly. The following possible development are noted:

1. Use of modern technology such as microprocessors to extract climate information from the real-time data flow. For example, certain space- and time-averaged statistical properties of the

satellite radiation measurements could be automatically acquired. The climate information could be derived from the composite observing system as well as from individual components of the observing system.

2. Increased use of satellite communication links to acquire data from remote locations.

3. Use of modern data storage, retrieval, and display systems.

4. Use of multiterminal links to these systems and to large computers.

In all of these possible developments it will be important to link the technological aspects of data management with scientific uses so that data sets of high quality and utility can be obtained. This will require investment in scientific manpower as well as electronic hardware (target date for implementation: 1983).

4.1.3 Development of Climate Data Sets from Noninstrumental Records

The general rationale for this work is developed in Section 3.2. Currently, there is considerable research in this area; but the task is large, and long-term support will be required. Some of this work will be done by individual scientists, but some will involve large collaborative efforts. The CLIMAP project is an example of a large, interdisciplinary effort to define the global climate at specific times in the past.

Highest priority should be given to the assembly of the following past climate data subsets:

1. The past 1000 years (for studies of climate variation on time scales of 10 to 100 years). This interval provides the possibility of year-by-year chronology in certain parts of the climate system over a time span that overlaps the instrumental record.

2. The past 30,000 years (for studies of climate variation on time scales of 100 to 1000 years). This interval is chronologically controlled by ^{14}C dating. The response of many parts of the climate system during a major climate change (glacial-interglacial) can be studied.

3. The past 1,000,000 years (for studies of climate variation on time scales of 1000 to 100,000 years). This interval has a reasonably good chronological control and a well-developed global record of changes in the ocean. Changes in global climate that appear to have a significant cyclic component can be studied.

These climate periods and time scales are most relevant for the program objectives in climate diagnosis, predictability, and sensitivity. The climate history of planet earth prior to several million years ago is certainly of interest and should be supported on its own merits, but several reasons suggest that it should not be given high priority now for purposes of this program. First, with increasing age, the climate record becomes progressively more fragmented, more difficult to read and to quantify, and loses

temporal resolution. Second, the older records provide insights mainly into the climate effects of changes in boundary conditions that occur very slowly, for example, changes in a continent's position. Third, the opportunities for paleoclimatologists to interact with physical climatologists and to employ conceptual and numerical models of modern climate are more numerous in dealing with the recent past.

The immediate task is to develop a more detailed plan for the gradual assembly of the data set most useful for meeting objectives of this program (Section 1.1). For each of the data subsets defined above, guidelines must be established for time and space sampling rates and accuracies. It will also be necessary to assess the resources required for field work, isotopic dating capabilities, and chemical and biological analysis capabilities. Long-term support of this work is required because the task cannot be accomplished in a few years. International collaboration will be essential (target date for a detailed plan: 1979)."

III. WORKSHOP PROCEEDINGS

LIST OF PARTICIPANTS AND OBSERVERS

Dr. James A. Almazan
National Advisory Committee on Oceans and
Atmosphere
Page Building 1
3300 Whitehaven Street, N. W.
Washington, D.C. 20235
(202) 254-8412

Dr. James R. Anderson
Chief Geographer
U. S. Geological Survey
Code 710
Reston, Virginia 22092
(703) 860-6344

Dr. Albert Arking
NASA/Goddard Space Flight Center
Code 915
Greenbelt, Maryland 20771
(301) 344-7208

Dr. David Atlas
Chief, Laboratory for Atmospheric Sciences
NASA/Goddard Space Flight Center
Code 910
Greenbelt, Maryland 20771
(301) 344-6925

Dr. Thomas S. Austin
Director, Environmental Data and
Information Service
Department of Commerce - NOAA
Page Building 2
3300 Whitehaven Street, N.W.
Washington, D.C. 20235
(202) 634-7318

Dr. Robert G. Bailey
U. S. Forest Service
Rocky Mountain Forest and Range Experimental
Station
240 West Prospect Street
Ft. Collins, Colorado 80526
(303) 221-4390

Dr. Roger G. Barry
World Data Center-A-Glaciology
Institute of Arctic and Alpine Research
University of Colorado
Boulder, Colorado 80309
(303) 492-6387
FTS 323-4311

Mrs. Carmen M. Benkovitz
Department of Energy
Brookhaven National Laboratory
Upton, New York 11973
(516) 345-4135

Dr. Chris Bernabo
Congressional Science Fellow
Office of Congressman George Brown
The United States House of Representatives
2342 Rayburn House Office Building
Washington, D. C. 20515
(202) 225-6161

Mr. Norman L. Canfield
NOAA Headquarters - OA22
Center Building
6010 Executive Boulevard
Rockville, Maryland 20854
(301) 443-8951

Mr. James Churgin
National Oceanographic Data Center
Page Building 1 - Room 404, D76
2001 Wisconsin Avenue, N. W.
Washington, D. C. 20235
(202) 634-7500

Mr. William K. Coblenz
Department of Energy
Energy Information Administration
2000 "M" Street, N. W.
Washington, D. C. 20461
(202) 254-3364

Mr. Philip M. Cohen
National Ocean Survey - NOAA
Code C2XS
6010 Executive Boulevard
Rockville, Maryland 20852
(301) 443-8241

Dr. Harold Crutcher
Private Consulting Meteorologist
35 Westall Avenue
Asheville, North Carolina 28804
(704) 253-2539

Mr. James F. Cunningham
NASA/Goddard Space Flight Center
Meteorology Program Office
Code 901
Greenbelt, Maryland 20770
(301) 344-7624

Mr. David C. Curtis
National Weather Service
Hydrologic Research Laboratory (W23)
8060 Thirteenth Street
Grammax Building
Silver Spring, Maryland 21701
(301) 427-7640

Dr. Paul C. Dalrymple
Engineering Topographic Laboratories
Department of Defense
Ft. Belvoir, Virginia 22060
(703) 664-1561

Dr. Raymond B. Daniels
Soil Conservation Service
U. S. Department of Agriculture
Post Office Box 2890
Washington, D. C. 20013
(202) 447-4991

Mr. Wayne L. Darnell
Langley Research Center - NASA
Hampton, Virginia 23362
(804) 827-2977

Dr. Wayne L. Decker
Professor, Department of Atmospheric
Sciences
University of Missouri
Columbia, Missouri 65201
(314) 882-6591

Dr. L. Denis Delorme
Government of Canada
Canada Centre for Inland Waters
Post Office Box 5050
Burlington, Ontario
CANADA L7R4A6
(416) 637-4227

Mr. Henry F. Diaz
National Climatic Center
NOAA/EDIS
Federal Building
Asheville, North Carolina 28801
(704) 258-2850 (ext. 765)

Captain Bernard C. Diesen, III
United States Air Force
AFGWC/NASA Liaison
Goddard Space Flight Center
Greenbelt, Maryland 20022
(301) 344-8556

Mr. L. David Drury
NOAA/EDIS/CEAS
Page Building 2
3300 Whitehaven Street, N. W.
Washington, D. C. 20235
(202) 634-7324

Mr. David Durica
Crop Condition Assessment Division
U. S. Department of Agriculture
FAS/CCAD
3200 Auditors Building
Washington, D. C. 20250
(202) 447-6277

Dr. Amos Eddy
State Climatologist for Oklahoma
The University of Oklahoma
School of Meteorology
200 Felgar Street - Room 219
Norman, Oklahoma 73019
(405) 325-2998

Mr. M. Douglas Edwards
U. S. Geological Survey
NAWDEX
421 National Center
Reston, Virginia 22092
(703) 860-6031

Dr. Edward S. Epstein
Director, Climate Program Office
National Oceanic and Atmospheric
Administration
EDIS/CEAS
Page Building 2
3300 Whitehaven Street, N.W.
Washington, D. C. 20235
(202) 634-7324

Dr. John E. Estes
NASA Headquarters
Code ERL-2
600 Independence Avenue
Washington, D. C. 20546
(202) 755-1201

Dr. Richard E. Felch
World Food and Agricultural Outlook
and Situation Board
U. S. Department of Agriculture
Room 1248 - South Building
Washington, D. C. 20250
(202) 447-7917

Dr. Albert J. Fleig
NASA Goddard Space Flight Center
Code 910
Greenbelt, Maryland 20771
(301) 344-5249

Col. Robert J. Fox, USAF
USAFETAC/CC
Scott Air Force Base, Illinois 62225
(618) 256-5066
FTS 255-5066

Dr. Elbert W. Friday
Director, Environmental and Life Sciences
Department of Defense
Pentagon - Room 3D129
Washington, D. C. 20301
(202) 695-9604

Mr. J. Patrick Gary
NASA Goddard Space Flight Center
Code 933
Greenbelt, Maryland 20771
(301) 344-6079

Dr. Donald L. Gilman
NOAA Climate Analysis Center
NOAA National Weather Service
W35 National Meteorological Center
Washington, D. C. 20233
(301) 763-8155

Dr. Richard L. Guthrie
Soil Conservation Service
U. S. Department of Agriculture
Matland Building #2
10000 Aerospace Road
Lanham, Maryland 20801
(301) 436-7333

Dr. Kenneth D. Hadeen
NOAA/EDIS/CEAS
Page Building 2 - D2X1
3300 Whitehaven Street, N. W.
Washington, D. C. 20235
(202) 634-7324

Mr. Galen F. Hart
Chief, Research Development Branch
U. S. Department of Agriculture
ESCS/SRD
South Building - Room 4833
Washington, D. C. 20250
(202) 447-8121

Dr. Alan Hecht
Climate Dynamics
Research Section
National Science Foundation
1800 "G" Street, N. W.
Washington, D. C. 20550
(202) 634-1547
FTS 634-1517

Mr. Gary A. Herbert
NOAA Research Laboratories
National Oceanic and Atmospheric
Administration
R329
Boulder, Colorado 80303
(303) 499-1000 (ext. 6842)

Mr. Steacy D. Hicks
National Ocean Survey
6001 Executive Boulevard
Rockville, Maryland 20852
(301) 443-8254

Dr. Joshua Z. Holland
Director, CEAS/EDIS
National Oceanic and Atmospheric
Administration
3300 Whitehaven Street, N.W.
Washington, D.C. 20235
(202) 634-7251

Mr. Eugene R. Hoppe
NOAA/EDIS/NCC
World Weather Building
Washington, D. C. 20233
(301) 763-8111

Dr. Frederick B. House
Department of Physics and Atmospheric
Sciences
Drexel University
32nd and Chestnut Streets
Philadelphia, Pennsylvania 19104
(215) 328-9527

Dr. Kent H. Hughes
NOAA/EDIS
2001 Wisconsin Avenue, N. W.
Washington, D. C. 20235
(202) 634-7510

Dr. Merton C. Ingham
National Marine Fisheries Service - NOAA
South Ferry Road
Narragansett, Rhode Island 02882
(401) 789-9326

Mr. Roy L. Jenne
NOAA/NCPO/CP
Room 705
6010 Executive Boulevard
Rockville, Maryland 20852
(301) 443-8981

Mr. William E. Klint
NOAA/EDIS/NCC
Federal Building D5X52
Asheville, North Carolina 28804
(704) 258-2850 (ext. 376)

Mr. Charles R. Laughlin
NASA Goddard Space Flight Center
Code 901
Greenbelt, Maryland 20771
(301) 344-6291

Mr. James D. Laver
NOAA, National Meteorological Center
World Weather Building
Room 201 - 5220 Auth Road
Camp Springs, Maryland 20233
(301) 763-8071

Mr. Sydney Levitus
Geophysical Fluid Dynamics Laboratory
NOAA
Post Office Box 308
Princeton, New Jersey 08540
(609) 452-6519

Mr. Harry F. Lins
U. S. Geological Survey
MS-710, National Center
Reston, Virginia 22092
(703) 860-7791

Dr. Julius London
Department of Astrogeophysics
The University of Colorado
Boulder, Colorado 80309
(303) 492-8759

Dr. Dudley G. McConnell
Associate Director
Data and Information Services
National Climate Program Office, NOAA
6010 Executive Boulevard
Rockville, Maryland 20852
(301) 443-8981

Dr. M. Patrick McCormick
NASA Langley Research Center
MS-234
Hampton, Virginia 23665
(804) 827-2466

Mr. Gordon A. McKay
Director, Climatological Applications
Branch
Canadian Climate Center
Atmospheric Environment Service, Canada
122 Brooke Street
Thornhill, ONTARIO M3H5T4
(416) 667-4803

Dr. Douglas R. McLain
National Marine Fisheries Service, NOAA
c/o Fleet Numerical Weather Central
Monterey, California 93940
(408) 373-3331

Mr. Daniel B. Mitchell
Director, National Climatic Center
NOAA/EDIS D5
Federal Building
Asheville, North Carolina 28801
(704) 258-2850

Dr. Harry Moses
Department of Energy
EV-302 MS E-201
Washington, D. C. 20545
(301) 353-5572

Mr. Ernest A. Neil
Chief, Meteorology Program Office
Goddard Space Flight Center
Code 901
Greenbelt, Maryland 20771
(301) 344-6291

Mr. Christopher D. Noe
NOAA/EDIS/NOPC
2001 Wisconsin Avenue
D782
Washington, D. C. 20235
(202) 634-7298

Dr. James P. Ormsby
NASA Goddard Space Flight Center
Code 913
Greenbelt, Maryland 20771
(301) 344-6507

Mr. Marion L. Parker
Forintek Canada Corporation
Western Forest Products Laboratory
6620 N. W. Marine Drive
Vancouver, British Columbia M552C6
(604) 224-3221

Dr. Stephen E. Pazan
Scripps Institution of Oceanography
A-030, SIO
San Diego, California 92093
(714) 452-3988

Ms. Karen W. Posey
NASA Goddard Space Flight Center
Code 933
Greenbelt, Maryland 20771
(301) 344-5083

Dr. Thomas D. Potter
Acting Director, EDIS - NOAA
Page Building 2
3300 Whitehaven Street, N. W.
Washington, D. C. 20235
(301) 443-8110

Mr. Robert G. Quayle
National Climatic Center, NOAA
Federal Building
Asheville, North Carolina 28801
(704) 258-2850 (ext. 765)
FTS 672-0765

Mr. Frank T. Quinlan
National Climatic Center, NOAA
Federal Building
Asheville, North Carolina 28801
(704) 258-2850 (ext. 245)
FTS 672-0245

Dr. P. Krishna Rao
U. S. Department of Commerce
NOAA/NESS/MSL
c/o NOAA - NESS
World Weather Building - Room 701B
Washington, D. C. 20233
(301) 763-8031

Dr. Eugene M. Rasmusson
Climate Analysis Center
NOAA, National Weather Service
5200 Auth Road
Room 604
Washington, D. C. 20233

Mr. Michael R. Riches
U. S. Department of Energy
OER
400 First Street, N. W.
Washington, D. C. 20585
(202) 376-9364

Dr. Ward R. Seguin
National Climatic Center
NOAA/EDIS
Federal Building
Asheville, North Carolina 28801
(704) 258-2850 (ext. 733)

Ms. Marilyn J. Shartran
World Data Center-A-Glaciology
(Snow and Ice)
INSTAAR
University of Colorado
Boulder, Colorado 80309
(303) 492-5171
FTS 323-4311

Mr. Charles R. Showen
U. S. Geological Survey
Automatic Data Section
Water Resources Division
MS 437
Reston, Virginia 22092
(703) 860-6879

Mr. August L. Shumbera
NOAA/EDIS/NCC
D5X5
Federal Building
Asheville, North Carolina 28801
(704) 258-2850 (ext. 376)

Dr. George I. Smith
U. S. Geological Survey
MS 26
345 Middlefield Road
Menlo Park, California 94025
(415) 323-8111 (ext. 2286)

Dr. Robert A. Schiffer
NASA Headquarters
EBT-8
Washington, D. C. 20546
(202) 755-8596

Dr. Morris Tepper
Head for Special Projects Office
NASA Goddard Space Flight Center
Code 910.2
Building 22
Greenbelt, Maryland 20771
(301) 344-7624

Mr. Otto W. Thiele
NASA Goddard Space Flight Center
Code 910.1
Greenbelt, Maryland 20771
(301) 344-7624

Mr. Douglas R. Troop
DOE/EIA
2000 "M" Street, N. W.
Room 7108J MS 461
Washington, D. C. 20461
(202) 254-7304

Mr. John L. Vogel
Illinois State Water Survey
Box 232
Urbana, Illinois 61801
(217) 333-4261

Mr. Fred B. Warren
United States Department of Agriculture
Room 4825 South Building
Washington, D. C. 20250
(202) 447-4795

Dr. Thompson Webb
Department of Geological Sciences
Brown University
Box 1846
Providence, Rhode Island 02912
(401) 863-3338

Mr. Louis A. Westphal
USAFECTAC/OL-A
Federal Building
Asheville, North Carolina 28801
(704) 258-2850 (ext. 201)

Mr. Donald R. Wiesnet
NOAA/NESS/ESG
World Weather Building
Room 810
Washington, D. C. 20233
(301) 763-8036

Dr. Jay S. Winston
NOAA/NESS
World Weather Building
Room 712C
Washington, D. C. 20233
(301) 763-8167

Mr. Arthur M. Woll
U. S. Geological Survey
514 National Center
12201 Sunrise Valley Drive
Reston, Virginia 22092
(703) 860-6741

Mr. Peter B. Woodbury
Deep Sea Drilling Project
University of California at San Diego
A-031
La Jolla, California 92093
(714) 452-3526

Mr. Vincent J. Zegowitz
COMM/NOAA/EDIS
2001 Wisconsin Avenue, N. W.
Page Building 1 - Room 427
Washington, D. C. 20235
(202) 634-7441

CLIMATE DATA MANAGEMENT WORKSHOP

AGENDA

MONDAY - May 7, 1979

5:00 - 9:00 P.M. Registration

Poolside (Indoor)

* * * * *

TUESDAY - May 9, 1979

SESSION I

PARLOR "A"

8:30 - 8:35 A.M. Call to Order - Objectives of Workshop
 8:35 - 8:40 A.M. Welcoming Remarks
 8:40 - 8:42 A.M. Introduction of Dr. Austin
 8:42 - 9:00 A.M. Opening Address
 9:00 - 9:15 A.M. U. S. Climate Program - Data Management
 9:15 - 9:45 A.M. Data Requirements for Research and Factors
 Inhibiting the Use of Climate Data

D. McConnell
 E. Epstein
 J. Holland
 T. S. Austin
 D. McConnell
 R. Jenne

9:45 - 10:00 A.M. * B R E A K *

Poolside

SESSION II

PARLOR "A"

10:00 - 11:30 A.M. Initial Organization of Working Groups

Conference Rooms

11:30 - 1:00 P.M. * L U N C H *

Dining Rooms

SESSION III

PLENARY SESSION - DATA USES AND NEEDS

PARLOR "A"

1:00 - 1:20 P.M. Department of AGRICULTURE
 1:20 - 1:40 P.M. Department of COMMERCE
 1:40 - 2:00 P.M. Department of DEFENSE
 2:00 - 2:20 P.M. Department of ENERGY

G. Hart
 J. Holland
 Elbert W. Friday
 H. Moses

2:20 - 2:40 P.M. * B R E A K *

Poolside

2:40 - 3:00 P.M. Environmental Protection Agency
 3:00 - 3:20 P.M. Natural Resources/Non-Urban Land Use
 3:20 - 3:40 P.M. Consulting Climatology
 3:40 - 4:00 P.M. State Climatology

H. Wiser
 G. Smith
 H. Crutcher
 W. Decker

4:00 - 7:30 P.M. * D I N N E R B R E A K *

(6:30 - 7:30 P.M. Chairmen's Oversight Group)**

SESSION IV

7:30 - 9:00 P.M. Working Group Sessions

Conference Rooms

** Oversight Group consists of the Working Group Chairmen, Workshop Support Staff Coordinator, Mr. Neil (COTR), and Dr. McConnell.

WELCOMING ADDRESS

May 8, 1979

Edward S. Epstein, Director
National Climate Program Office
National Oceanic and Atmospheric Administration

Mr. Chairman, Dr. Austin, Dr. Potter, Workshop Participants, friends, it is a distinct honor and pleasure to welcome you to this Climate Data Management Workshop. This is among the first real programmatic activities planned and implemented under the new National Climate Program. The Workshop is jointly sponsored by the National Climate Program Office and NOAA's Environmental Data and Information Service. And from the outset, we have conducted planning and preparations in an interagency, participative manner. This reflects one mode of how the Program Office will operate, but I will return to this point later on.

In just a few minutes this morning, I would like to give a list of the background that motivated the Workshop and then indicate some of the hoped for results of the Workshop from the National Program Office point of view. I understand that Tom Austin will discuss hoped for results from the EDIS perspective.

The U.S. National Climate Program formally came into being on September 17, 1978, when the President approved PL 95-367, the National Climate Program Act. The stated purpose of the Act is: "to establish a national climate program that will assist the Nation and the world to understand and respond to natural and man-induced climate processes and their implications." Let me emphasize the Congress in setting the policy basis for the program included both understanding and response. That might be termed research and application.

In arriving at its position, Congress held a series of hearings and among other things found that "Information regarding climate is not being fully disseminated or used, and Federal efforts have given insufficient attention to assessing or applying this information." And further, that: "the United States lacks a well-defined and coordinated program of climate-related research, monitoring, assessment of effects, and information utilization."

Thus, Congress mandated a program which emphasizes integrated planning among Federal agencies and authorizes an Inter-governmental Program with State agencies. Specifically regarding climate data and information, the list calls for:

- global data collection, and monitoring and analysis activities to provide reliable, useful, and readily available information on a continuing basis;
- systems for the management and active dissemination of climatological data, information, and assessments, including mechanisms for consultation with current and potential users; and
- measures for increasing international cooperation in climate research, monitoring, analysis, and data dissemination.

I have here only quoted some relevant highlights of the Act. A comprehensive review of the Act and Conference Report will go even further to show the Congress' strong desire to see reliable data and information being actively used to increase the effectiveness of planning operations in both the public and private sector of our activities.

The Academy's Climate Research Board also recognized the vital role of climatic data. The CRB recommended emphasis on the use of climate knowledge to serve the economy. The CRB states explicitly that for climatic data to be useful, they must be accessible and effectively disseminated to users.

Thus, the goals of this Workshop are right in line with the National Program. We interpret the goals as follows:

1. To further progress on an inventory of climate data. We recognize that agencies have begun the tasks of inventorying and cataloguing their data bases. Yet, comprehensive data sets may call for contributions from several agencies -- for example, say precipitation from NOAA, streamflow from USGS, snow cover from USDA. Thus, an effective access system would require coordinated access strategies among the agencies.
2. To make a preliminary assessment of the status of data sets in relation to requirements. This is recognized as an elusive goal in that there are myriad requirements. The feeling is that there are enough stated and known requirements that certain general assessments can be made. To that end, there are many "users" represented here at the Workshop.
3. To recommend steps to increase the accessibility of the data. This is very key. NASA's experience in compiling the Nimbus Ozone Data Set is ample evidence that simply having the data is a long way from having

the data in an accessible, usable condition. This also raises the point that there is often a lot of expense and effort required to bring data holdings to the most effective condition. Difficult trade-offs may have to be made and priorities need to be set.

4. To recommend steps and activities following the Workshop to achieve the goals. Finally, we recognize that this Workshop is a step in a process that began earlier and will continue. There may need to be periodic workshops of this type. Nevertheless, we hope this gathering will give us its views on our planning and additional efforts that may be needed to assure a successful, fully effective Data Management Program.

I will conclude now by thanking you for taking time away from your very busy schedules to take part in the Workshop. It is gratifying to me, that the Office and the National Program are receiving so much support from the community --, the agencies, universities, private sector. I look forward to hearing your recommendations.

OPENING ADDRESS

May 8, 1979

Thomas S. Austin, Director
Environmental Data and Information Service
National Oceanic and Atmospheric Administration

Good morning:

Objective premise--need for national and global climate data bases--meet needs evergrowing number and sophisticated users. I can think of no better way to express and underline the reason for the importance of this workshop with respect to the National Climate Program than to quote Bishop Epstein on the subject.

In a recent article in EDIS magazine, in discussing the various elements comprising the climate program, he notes that:

"...although it does include research to increase our understanding of climate processes, the emphasis is clearly on providing more and better climate information, on identifying and quantifying the impact of climate and climate fluctuations, and on delivering climate information and services to users."

And, in discussing elements which deal specifically with data collection and management, he states:

"Again, the emphasis is on end products: 'reliable, useful, and readily available information, and active dissemination of ... information and assessments.' There also is an added caveat that there be consultation with current and potential users. The message is very clear. The purposes of the program are to provide information, to assure that there are means to determine what information is most needed, and to stimulate its wide application."

These comments on the NCP Act by Dr. Epstein provide the orientation and conceptual framework for your work. Unfortunately, although similar sentiments have been voiced in the past, it is a concept seldom implemented.

For example, a few years ago, a National Science Foundation contractor asked more than 200 top Federal executives where they go their science information. Their answers? Mostly from newspapers.

And many of these "decisionmakers" controlled Federal information systems.

I think that anyone who has been involved in or followed the public and Congressional debates that preceded the passage of the National Climate Program Act would agree that this unfortunate condition applies to some degree to climatic data and information.

Certainly the Congress feels that way, for the Act itself states:

"Information regarding climate is not being fully disseminated or used, and Federal efforts have given insufficient attention to assessing and applying this information."

We have not been making use of existing data and information and mounting expensive programs to generate more for a specific program of purpose. We have to get away from the all-too-familiar "not-invented-here" syndrome and, through interchange and cooperation, make maximum use of existing resources. The inventory you have been asked to begin is a critical step in this process.

Another real-life parable for us to contemplate concerns the European Nuclear Documentation Service (ENDS) in Luxemburg. In 1974, it was the largest automated information system in Europe and the third largest in the world.

ENDS computer files then contained nearly 1.5 million articles on nuclear energy. Some 45 to 50 people worked on file maintenance and user searches. The service was free. Yet, despite this tremendous resource commitment, there were, on the average, only three users a day.

In commenting on the situation, Dr. George Anderla of the Sorbonne concluded:

"...The system does not provide the information the users want or need because we know the users requirements only superficially."

I would ask you to keep this statement in mind during your workshop, so that we do not repeat this unfortunate, extremely expensive, but very common mistake. For, as Dr. Anderla also concluded:

"...This kind of situation cannot go on very long, because no government...will allow millions of dollars to be spent for such limited use and for such a restricted number of users."

I am sure that this also is true of our Government and of any limited and restricted data management system we might develop to implement and support the National Climate Program Act.

Who is the user? Who are the users? It is clear from our own experiences at EDIS that the climate-related data and information user audience encompass a much larger group than the scientist, engineer, and government manager. It includes public policy makers and politicians at the national, state, and local levels; attorneys, regional planners, businessmen, citizen's groups and individual taxpayers.

At the same time, increasing public concern over environmental, ecological, energy, and other issues with a scientific base has been shifting environmental, particularly climatic, data applications emphasis from the advancement of scientific knowledge to using that knowledge to solve global and national problems. These include potential world food shortages the energy crisis, environmental pollution, climatic anomalies such as the recent run of cold winters, planning for the development of the coastal zone, and even the ill effects of weather and climate on human health. Decisionmaking processes--aid (40,000)-- CEAS climate/food/energy/health--GNP.

Many of these new users require data and information in different forms than those traditionally provided to the scientist and engineer, and their applications frequently require multidisciplinary assessments and interpretations. This, in turn, requires greater emphasis on packaging data to meet user needs. Again, to echo Dr. Epstein, the emphasis of the National Climate Program Act is on end products-- it is not on building yet another governmental--intra-government--data and information system.

Many of the products will have to be understandable to the layman. In addition, there must be emphasis on packaging information to meet user needs that cut across traditional (and convenient) divisions by discipline, mission, program, and agency. To quote a phrase being heard more and more frequently in the halls of science, particularly at budget time, our products must have "social relevancy." Son of IDOE.

During the coming decade, we expect the volume of user requests for multidisciplinary environmental data to continue increasing, many new data applications to be developed, and user demands for shorter response time to accelerate. To meet these and other user needs, and to achieve the degree of data integration needed to meet national needs, EDIS is integrating its own formerly separate data base operations under a single data archive management and users services system.

In implementing the new system, the data bases of the National Oceanographic Data Center, the Center for Environmental Assessment Services (Washington, D.C.), and National Geophysical and Solar-Terrestrial Data Center (Boulder, Colo.) with the data base of the National Climatic Center in Asheville, N.C., the largest climatic data base in the world, will, through referral and merging processes as appropriate, provide for multidisciplinary data and product services. Telephone lines and communications equipment already have been installed at the Washington and Boulder-based centers to provide a direct link to NCC. The installation of a high-density mass-storage system at NCC will increase the amount of data accessible on-line, and further reduce costs and response time.

What will all this mean to the user? It will mean that multidisciplinary requests that today might take several weeks to answer, will be answered in an hour or two. And relative to present costs, the quicker answer will cost less; it will be cheaper for EDIS to provide the answer, and the savings will be passed on to the user. Moreover, the sophisticated user with his own terminal will be able to plug directly into the system. And the user will get better data products; instead of three separate products in three different formats, the output will be an integrated, designed product.

Within the last two years, EDIS has sponsored or cosponsored a series of data management workshops ranging in subjects from marine geology to climate and health. Some of these workshops such as the paleoclimate workshop cosponsored with the National Science Foundation in November, were designed to provide a basis for further deliberations at this workshop.

The range and variety of skills and activities represented here today attest to recognition of both the importance of data management to the National Climate program and to the potential for success of this workshop. We need your guidance to develop the desired referral capability, the national and global data bases and to implement an optimum data management system, one that will be responsive to all the users of climate data and information. Without detailed, firm guidance, data management systems and centers are prone to turn out products that may be unwanted and thus unused, either because the users do not understand or relate to the product, or they do not know that the product is available.

Remember the example of ENDS that I cited at the beginning? I would hope that the acronym will prove prophetic, at least as far as the data management system we are developing is concerned, and that we will not, as so many before us have, reinvent a socially (or politically) irrelevant data management system.

The degree of cooperation called for if the National Climate Program is to be successful is far beyond any demonstrated to date by agencies, institutions, and individuals working in this field. I hope that this Workshop will provide proof that such cooperation is not only possible, but productive.

Thank you.

THE NATIONAL CLIMATIC CENTER
CURRENT STATUS AND FUTURE PLANS

Daniel B. Mitchell, Director
National Climatic Center
NOAA/EDIS

INTRODUCTION

The National Climatic Center (NCC) is the national archive for climatological data. Data observed by the National Weather Service network, cooperative network, satellite systems, and other national sources are archived. Data are both in manuscript or hard copy form and in digital form. However, digital data comprise only a portion of the total NCC data archive.

The National Climatic Center also provides user services. Approximately 66,000 customer requests were answered last year. The number of customers serviced each year has been steadily increasing for the last seven years. The type of customer requests include requests for data and information which has been tailored to meet the customer's request. As a result of the emphasis placed on services by the Climate Act, we anticipate that the National Climatic Center's services to the customer will increase dramatically over the next several years.

The NCC is located in Asheville, North Carolina. The Center is divided into six Divisions and two Staff Functions. One of its Divisions, the Satellite Data Services Division, is located in Camp Springs, Maryland; and is a special Center within itself.

The Administrative and Technical Services Division is responsible for the administrative and logistical support for the NCC. Their functions include printing plant operation, personnel services, procurement, budget and fiscal functions, and space allocations.

The Automated Data Processing Services Division is responsible for ADP support to the Center. Their functions include computer operations, data translation, and systems design and operations.

The Data Operations Division is responsible for processing of the climatological data. All climatological data received by the NCC are processed by the Data Operations Division. Their functions include the receipt, inventory, edit and verification, and the preparation of special publications of the data.

The Climatological Applications Division is responsible for the development of climatic applications tailored to the customers' requests. Their functions include the preparation of summaries, statistical analyses, and assessments.

The Information Services Division (ISD) is the NCC interface between the Center and its customers. The ISD basic function is to provide user services and manage the manuscript archives.

The Satellite Data Services Division, located in Camp Springs, is responsible for archiving satellite data from NOAA operational satellites and for providing user services from these archives. Since the Satellite Data Services Division is not collocated with the NCC, they are also responsible for their data processing, user services, and ADP support functions unique to the satellite data services.

In addition to the six Divisions I have just described, we have the Information Management Center and the Data Administrator assigned to the Director's Staff. The Information Management Center is responsible for the receipt of all correspondence and making distribution of this correspondence within the Center. It is also responsible for word processing. We currently utilize up-to-date word processors and a Center-wide dictation system to allow for general correspondence preparation within the Center.

The Data Administrator with the Data Base Administration Staff is responsible for the design, development, maintenance, and management of the NCC digital data base. This staff function has just recently been added to the Director's Staff.

GOALS AND OBJECTIVES

In the process of serving thousands of customers over the last several years and through the participation in numerous user workshops held over the past three years, we have identified firm user requirements for climatological data. By analyzing these data requirements and reviewing our data management practices, we have identified several principal problems with the NCC data base. In an effort to provide better customer services, we have established four basic goals, which we hope to achieve over the next 7 to 10 years. These goals are: (1) modernize NCC by automating manual data processing functions and by providing automated support to user services; (2) improve the data base by providing better quality control, more comprehensive inventory of data, and by providing a more complete digital data base; (3) develop an interactive digital

data base by making more climatological data available on-line to a computer system under a data base management system; (4) provide user access to NCC data base by providing a capability for State Climatologists and certain other customers access to the NCC data base by remote terminals.

In an effort to meet these specific goals, NCC has developed a short- and long-term plan. In subsequent paragraphs, I shall discuss objectives we have established, actions we are planning, and actions we have already completed in an effort to meet our goals.

In our processing of climatological data for archival and user services, we still employ many manual procedures. With the current ADP technology available today, we have an opportunity to more completely automate our data processing. For example, we manually reduce many data recorded on strip charts onto a data entry form and then key entry the data into digital form by using a key-entry device. This function can be more completely automated by utilizing a digitizer with pen and tablet and going directly from a chart to digital information. Additionally, the NCC receives weather observation data in manuscript form from the National Weather Service observing stations. These data are collected and converted into digital form via an Inforex key-entry system. In the future, the National Weather Service plans to implement the AFOS system. The operational date is scheduled for 1979. The NCC is a spur on this system, and as a result, will receive all the weather observation data on this system in digital form. Thus, this will alleviate the manual key-entry of data from manuscript form which we do today.

In our contact with the user community, we have learned new requirements for data quality control. The user wants better quality control of data, and that data which is quality controlled, the user wants information about the quality of the data. Hence, we plan to develop new edit and validation programs for the surface-upper air, cooperative, solar, and marine surface data sets. The development of new programs has already begun and is planned to be completed by 1981.

Along with the development of new edit and validation programs, NCC has initiated a project to develop a data base inventory. The project has been initiated this year and shall be completed by 1984. Once this project is completed, NCC and NCC users shall know what data are available in both manuscript and digital form at NCC.

In an effort to develop a better quality data base, NCC has also initiated the procurement of a Quality Assurance Graphical Subsystem. This system, when installed, shall give the data validator an interactive capability whereby he can graphically review data that have

been identified as suspect in the process of editing and validating of the particular data sets previously mentioned. This system, when implemented, shall give NCC a capability to more readily examine and to more quickly complete validation of data. This system is planned to be implemented in 1980.

The NCC is also in the process of procuring a new computer output to microfiche system. The NCC produces many publications, summaries, and tabulated data each year in support of customer requirements. The capability of the new computer output to microfiche system will provide NCC additional capability to more readily tailor products to the user requirements. This new system is scheduled to be installed and implemented late 1979.

Today NCC has access to some 75,000 magnetic tapes which contain digital climatological data. This large, cumbersome tape resource is difficult to manage and often difficult to access economically. As a result, NCC is in the process of procuring a mass store subsystem. With the installation of the mass store subsystem, NCC plans most of the digital data contained by the magnetic tapes onto the mass store subsystem to make it available on-line to the computer system. Once data are loaded into the mass store subsystem, quicker access and more cost effective access to the data will be a reality. Another objective within our plans is to implement an interactive data base between 1981 and 1984. I shall discuss this further in subsequent sections under the 1981 initiative.

Current and planned satellites in the Geostationary Operational Earth Satellite (GOES) series of NOAA operational geostationary satellites are collecting and will collect unprecedented volumes of data. These data in their original digital forms, or processed imagery data, represent a valuable national asset with significant retrospective application potential in the areas of oceanography, marine biology, coastal management, deep water port planning, climatology, solar insolation climatology, severe weather meteorology, hydrology, and agriculture. Presently, NCC archives only processed imagery and only a small amount of digital GOES data. This limited archive is inadequate to meet the user needs because users are presently limited to copies of this imagery only, and cannot specify the coverage, enhancement, and resolution required to best meet their needs. The potential benefit of GOES data in the areas cited above can only be met by archiving the full-resolution digital data, and by providing the capability of producing from the archived data the digital and image products required by the user community. Hence, NCC has as an objective to procure and implement a GOES data archive/service system. Our goal is to implement this system by 1981. Once implemented, this system would provide us with the capability to archive GOES satellite data for a period of 5 years and to provide services from this archive.

Our long-term plans are to upgrade our computer system in the 1984 period. With the Climate Act stressing customer services, we anticipate that our user requests will continue to climb at an even higher rate than they have in the past several years. Hence, we believe that we will need to upgrade our current system to meet the future demands.

Also in the same time frame, we are planning to provide access to the NCC data base to the State Climatologists and limited other users who will require a near real-time access to a climatological data base. Such access would be through a remote job entry terminal or a time share terminal. We are currently looking in the 1985 time frame for this type of interface. Today we do not possess the capability to have users other than internal to NCC access to the NCC data base. First, before we can provide such access, NCC must develop the interactive data base, which I will address later, and also enhance its ADP system capabilities.

Many actions have already been initiated and some have been completed in our effort to meet our goals. NCC is in the process of microfilming some 80 million manuscript weather records. The microfilmed data are being inventoried and indexed in the process of microfilming. This is being done so that the recently established Micrographics Service Center can readily retrieve microfilmed data in the servicing of customers.

In an effort to modernize NCC, a Univac 1100/10 was recently installed and is operational at NCC. We are in the process of program conversion, and hope to have this particular effort completed by late summer. A data digitizer has been purchased and implemented in our Cooperative Data Branch. The digitizer is being used to automate the input of cooperative data into digital form. An additional three digitizers will be added later this year to complete the automation of that function.

In the satellite data archive and services area, NCC has recently completed action to procure an Image Display and Hardcopy Subsystem. Once implemented, this subsystem will enable the Satellite Data Services Division to more efficiently tailor satellite data products to the customer needs. Additionally, a mass store subsystem was installed in our Satellite Data Services Division to archive satellite data from TIROS-N.

Due to our major effort in the development of our data base, I have established a Data Base Administration Staff to manage the NCC Data Base. This staff is responsible for the design, development, and implementation of the data base management system and to restructure the data base so that it can be more easily accessible for servicing customers.

NCC 1981 INITIATIVE

As I previously mentioned, one of the objectives for NCC is to develop an interactive digital data base. For NCC to complete the development and implementation of this digital data base would take approximately 7 to 10 years. However, with the emphasis that the Climate Act places on services, we feel that we must develop this data base much sooner than we could normally do it with the existing resources. Therefore, we have submitted an initiative for 1981 requesting additional resources which will enable us to accelerate the development of this data base. We are planning to complete the development of this interactive data base in approximately 5 years if additional resources are made available over the entire period. Over the history of NCC, hundreds of data sets have been established in response to, and in a mode dictated by, then existing observation systems and data needs. These data exist in digital form on thousands of computer tapes in various forms and documents. The large digital files are cumbersome, extremely expensive to use, and contain numerous duplicates and specialized products. The data vary in quality due to changes in existing procedures dictated by changes in regular/special observing systems, technology, and data requirements throughout the NCC history. There is a serious lack of comprehensive documentation including inventory information. Gaps and inconsistencies in and between the digital sets require specialized editing techniques in processing data from hard copy records to make the data available in forms which are cost and time effective, relative to existing and projected national needs. These problems make it difficult and expensive to provide users with required data and information.

In the development of the interactive data base, we plan to complete the development of data sets by filling in missing observations and extending the period of record. Also, data will be merged and restructured to minimize use of cumbersome media. Duplicate data sets will be eliminated.

To provide better quality of data, NCC will more completely automate and standardize data editing and validation. Additional validation will be performed on data as necessary, and the data quality will be flagged so that this information can be passed on to the users.

As the interactive data base is being developed, it will be loaded under a data base management system. In an effort to improve the access and reduce the cost to the users, NCC will restructure the data base based on user statistics so that the access becomes more economical.

In summary, the initiative will provide:

- Edited, validated, and compacted historical data files.
- Complete data files.
- Ultra long periods of record for selected stations.
- Improved digital station library.
- Reduced data costs to users.
- Enable quicker response to users.
- Enable NCC to tailor data products to users.

The principal data sets that NCC is planning to put into the interactive data base are: U. S. hourly airway surface observations, global marine surface observations, U. S. summary of day and month observations, global rawinsonde observations, hourly precipitation data, and selected global surface observations.

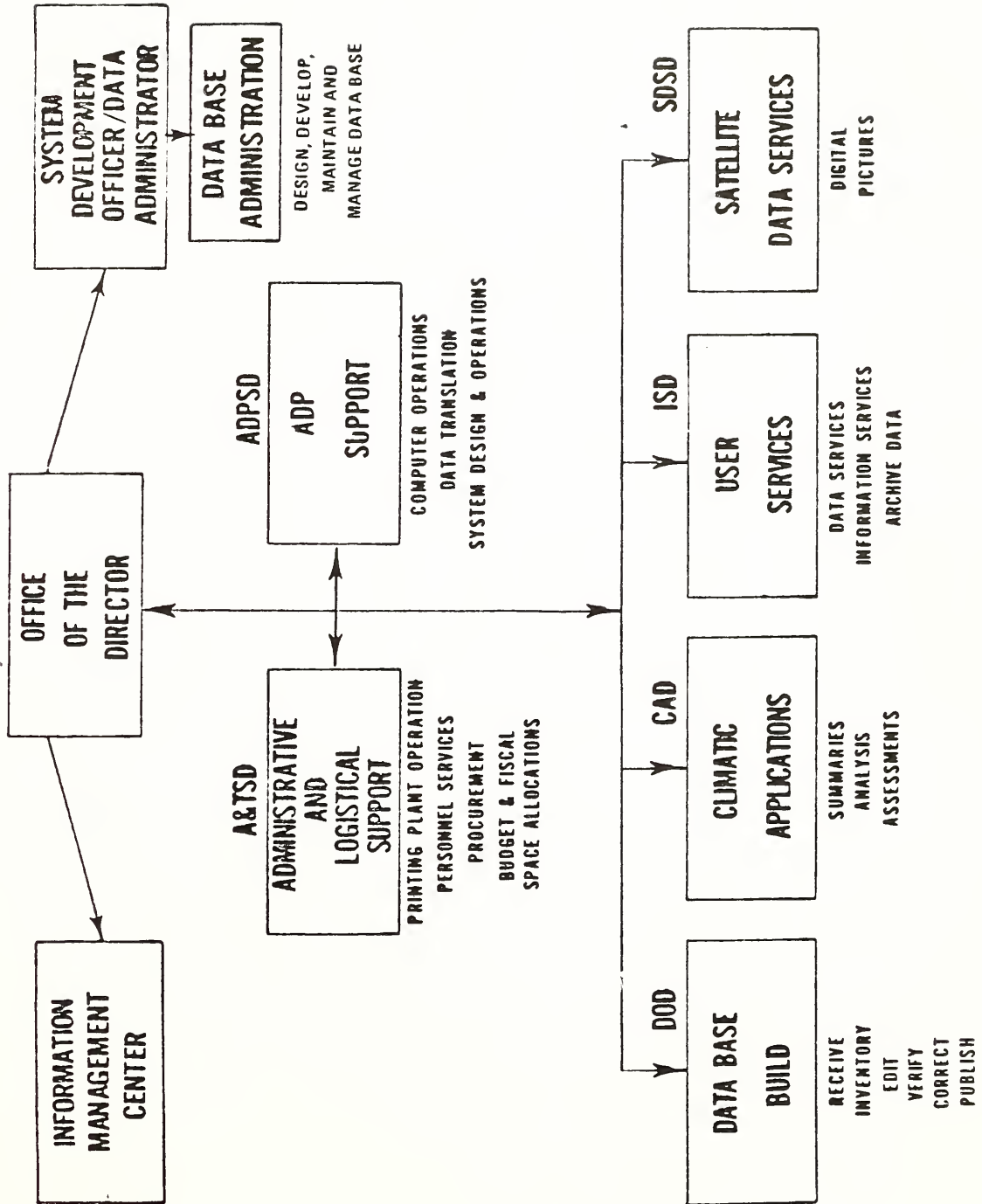
SUMMARY

The NCC is presently embarked on a massive rehabilitation of all its processing systems. New hardware, new software, and new ideas and procedures will enable NCC to process the data in a more automated fashion. We anticipate that much of these upgraded processing systems will be implemented within 2 years. These new processing systems, coupled with current development of a modern data base management system and an interactive data base, will provide the facility to rapidly and inexpensively access and service the large amounts of data required by the Climate Program and other national interests including our current customer base. The development of the interactive data base is a long-term project considering our current level of resources. However, with the support of the 1981 initiative, and subsequent additional resources during the period through 1984, we would hope that we can complete the development of the data sets and the interactive data base by the end of 1984.

The following graphs and information were presented at the Climate Data Management Workshop, May 8-11, 1979, at Harpers Ferry, West Virginia.

MONTH	1972	1973	1974	1975	1976	1977	1978	1979	TOTAL
JAN	23,305	36,908	47,073	52,895	56,342	63,074	64,313	63,076	
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									
JUN									
DEC									
JAN									

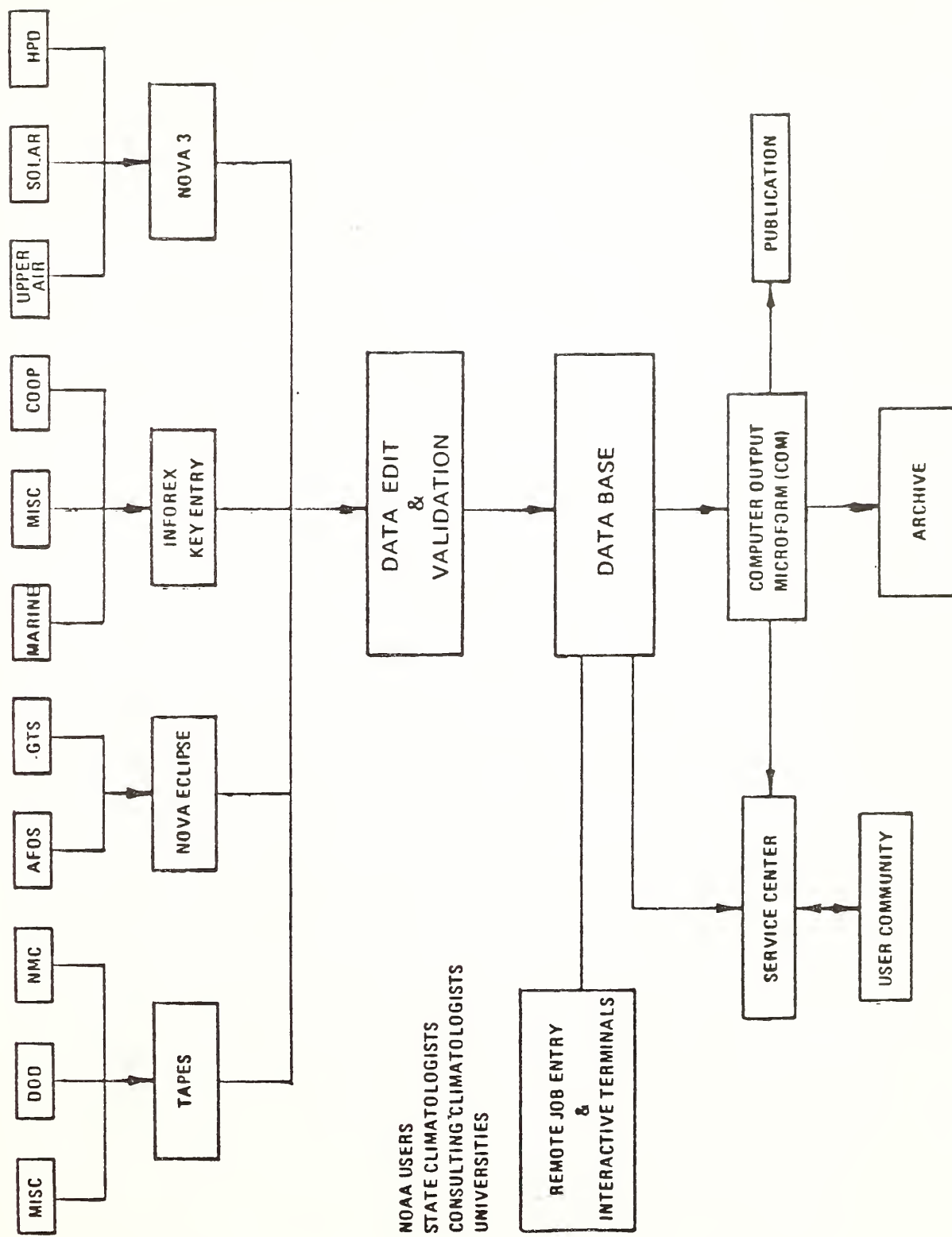
NATIONAL CLIMATIC CENTER FUNCTIONAL ORGANIZATION CHART

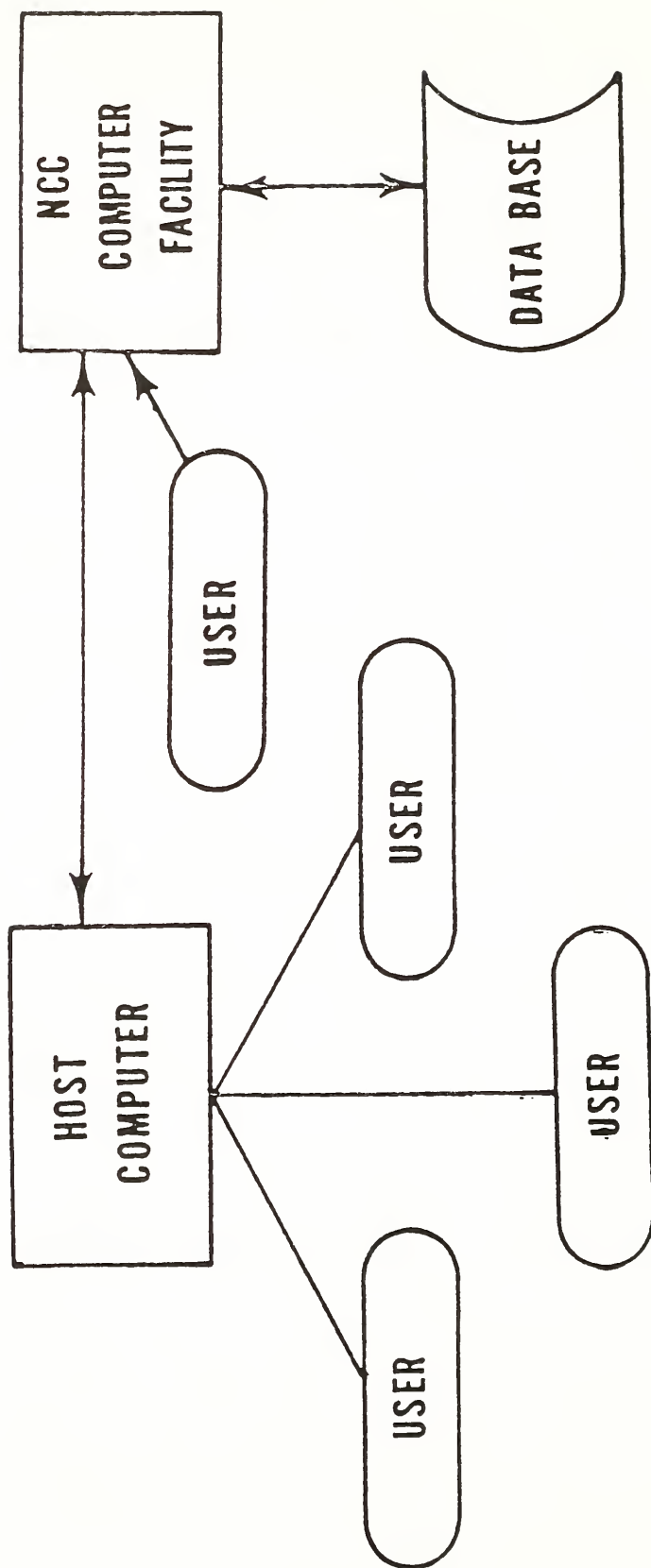


GOALS AND OBJECTIVES

- MODERNIZE NCC
 - DATA PROCESSING
 - USER SERVICES
- IMPROVE DATA BASE
 - MORE COMPLETE DIGITAL DATA BASE
 - BETTER QUALITY CONTROL
- DEVELOP INTERACTIVE DATA BASE
- USER ACCESS - NCC DATA BASE

NCC AUTOMATED DATA MANAGEMENT SYSTEM





USER/USER HOST DATA BASE COMMUNICATIONS INTERFACE

SHORT AND LONG TERM PLANS

- COMPLETE AUTOMATION DATA INPUT
 - DIGITIZERS—1979
 - AFOS—1979-81
 - GTS—
- IMPLEMENT DBMS/TEST DATA SET-1979
- NEW DATA EDIT PROGRAMS
 - SURFACE
 - UPPER-AIR
 - CO-OP
 - SOLAR
 - MARINE1979-81
- NCC DATA BASE INVENTORY 1979-1984
- NEW COM - 1979
 - COMPUTER OUTPUT TO MICROFICHE
- QUALITY ASSURANCE SUBSYSTEM - 1980
- MASS STORE SUBSYSTEM -1981
- INTERACTIVE DATA BASE -1981-1984
- GOES DATA ARCHIVE/SERVICE SYSTEM - 1981
- COMPUTER UPGRADE -1984
- ACCESS-NCC DATA BASE -1985
 - STATE CLIMATOLOGIST
 - AND LIMITED OTHER USERS

ACTIONS COMPLETED

- WORD PROCESSING SYSTEM IMPLEMENTED
- MASS STORE SUB SYSTEM - SATELLITE DATA BASE
- UNIVAC 1100/10 INSTALLED
- DATA DIGITIZERS (COOP DATA)
- IMAGE DISPLAY/HARDCOPY SUB SYSTEM
PROCURED - SATELLITE DATA
- MICROGRAPHICS SERVICE CENTER
- DATA BASE ADMINISTRATION STAFF
- MICROFILM OF MANUSCRIPT DATA
- INVENTORY/INDEX OF MICROFILM DATA

THE NCC 1981 INITIATIVE

DESIGN AND INITIATE AN INTERACTIVE DATA BASE (DIGITAL)

I COMPLETE

- FILL IN MISSING OBSERVATIONS
- EXTEND PERIOD OF RECORD

II COMPACT

- ELIMINATE DUPLICATE DATA SETS
- MINIMIZE USE OF CUMBERSOME MEDIA
- MERGE DATA

III EDIT AND VALIDATE DATA

- AUTOMATE AND STANDARDIZE EDITING
- PERFORM ADDITIONAL VALIDATION
- INTERACTIVELY REVIEW
- ADD QUALITY FLAGS

RESTRUCTURE DATA BASE

- REFORMAT
- IMPROVE ACCESSIBILITY

THIS INITIATIVE WILL PROVIDE...

- **EDITED, VALIDATED AND COMPACTED
HISTORICAL DATA FILES**
- **COMPLETE DATA FILES**
- **ULTRA-LONG PERIOD OF RECORDS FOR
SELECTED STATIONS**
- **IMPROVED DIGITAL STATION LIBRARY**

ALSO, THE INITIATIVE WILL:

- **REDUCE DATA COST TO USERS**
- **ENABLE QUICKER RESPONSE TO USERS**
- **ENABLE NCC TO TAILOR DATA PRODUCTS**
- **PROVIDE NCC WITH FACILITY
TO TAILOR SUMMARY INFORMATION**

PRINCIPAL CANDIDATE DATA SETS FOR INTERACTIVE DATA BASE

- U.S. HOURLY AIRWAYS SURFACE OBSERVATIONS
- GLOBAL MARINE SURFACE OBSERVATIONS
- U.S. SUMMARY OF DAY AND MONTH OBSERVATIONS
- GLOBAL RAWINSONDE OBSERVATIONS
- HOURLY PRECIPITATION DATA

NCC SYSTEM OBJECTIVES

- **ACCESSIBILITY**
- **FLEXIBILITY**
- **INPUT & STORAGE CAPACITY**
- **PRODUCTIVITY**
- **RESPONSIVENESS**
- **COST TO NOAA & USERS**

DATA REQUIREMENTS FOR RESEARCH AND
WAYS TO PROMOTE THE USE OF
CLIMATE DATA

May 8, 1979

Roy L. Jenne, Manager
Data Management Activities
National Climate Program Office

We want to welcome you to the Data Management Workshop. We will first discuss the data requirements for research. John Kutzbach has prepared some written material about science requirements but wasn't able to attend this meeting. Then we will discuss considerations that may be useful in your working group deliberations about what is needed in order to make climate data in each discipline area more accessible.

History

First, we will present a very sketchy history of the climate activity that has led us up to this point. The Joint Organizing Activity (JOC) was organized by agreement between WMO (World Meteorological Organization) and ICSU (International Council of Scientific Unions) in 1967. Its charter called for research to promote understanding of both weather and climate problems. In 1972 there were a number of important anomalies in the world's weather including a drought in the USSR; the USSR purchased significant amounts of U.S. wheat, leading to sharp increases in grain prices. In 1973 a report was published showing relationships between growing season weather and the yield of crops.

In 1973 Mitchell and Fletcher prepared a report on the ending of the interglacial. In the last million years, the world's climate has normally been cooler than it is now. Until about 1978, there were many articles reaching the public that implied a rather large chance of a rapid shift in the world's climate toward cooler mid-latitude conditions, a shorter growing season, and more droughts.

In 1974 there was an international meeting of climate experts in Sweden to discuss the physical basis of climate and climate modeling. The product of the meeting was the often quoted "JOC-16" report (GARP publication number 16.) In 1973-74 many people were becoming more active in Federal climate planning through separate activities undertaken by ICAS and a subcommittee of the President's Domestic Council; locally this included R. White, J. Fletcher, E. Radok, E. Epstein, W. Sprigg,

R. Lavoie, and others. Fletcher and others encouraged me to accelerate the collection of data information, which led to a publication concerning data for meteorological research in 1975. Between about 1973 and 1977, many were involved in the preparation of the Domestic Council Report: "A United States Climate Program" in 1974; and the ICAS plan: "A United States Climate Program Plan" published in 1977.

The GARP Activities Office of the JOC called a working group meeting in Princeton in April 1976 to prepare a small report "The Global Data Base for Climatic Research." I was asked to prepare further information about climate data. This led to the report that you have seen: "The Global Data Base for Climate Research"; it still has not been completed.

From about 1975-78, NASA appointed a "NASA Science Working Group" to help refine climate requirements. NASA used this and other information to prepare the NASA Climate Plan published in 1977. In 1978 NASA (at Goddard) printed "Candidate NASA Data Sets Applicable to the Climate Program." Karen Posey gathered most of the material for it. In 1978 the NAS report on the "Research Strategy for the U.S. Climate Program" was published. In the summer of 1978, the NAS Climate Research Board met to discuss the U.S. Climate Program. The political interest in climate was enhanced by the cold winters in the eastern USA of 1976-77 and 1977-78.

President Carter signed the Climate Act in September 1978. There was a WMO working group meeting on climate data management in November 1978. The National Five-Year Preliminary Climate Plan was published (first version) in April 1979.

Data Requirements for Research

Figure 1 shows many of the components of the climate system. It is our job to make sure that the data necessary to monitor and study the different components is as available as possible. In some cases this will require improvements in observing systems. The observing strategy is not our main concern in this workshop.

The 1978 NAS research strategy report, listed data needs as follows:

1. Prepare data from the instrumental record.
 - Assemble "1950-Present" data set.
 - this includes: surface synoptic data and upper air data (rawinsonde, satellite, and aircraft)

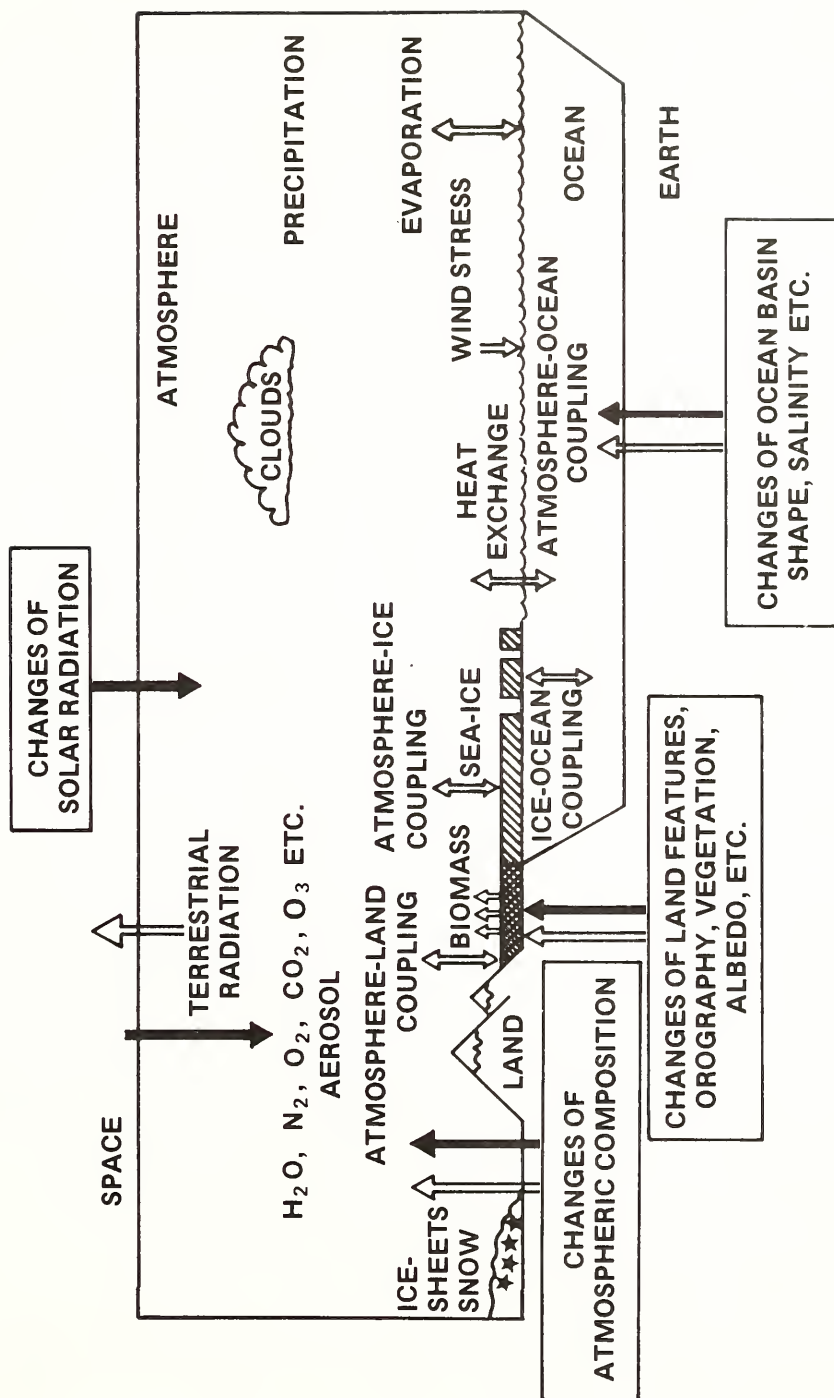


Figure 1.—Schematic illustration of the components of the climatic system. The full arrows (\rightarrow) are examples of external processes, and the open arrows (\Rightarrow) are examples of internal processes in climatic change (Adapted from Report of the Panel of Climatic Variation to the U.S. GARP Committee, 1974.)

- Assemble long-term instrumental data.
 - data from stations starting in the 1700s and 1800s
 - Assemble compressed FGGE data set.
 - time and space averaged statistics
2. Develop a non-instrumental data base.
- Recent 1,000 years.
 - to study changes for time scales 10-100 years
 - Recent 30,000 years.
 - to study time scales of 100-1,000 years
 - Recent 1,000,000 years.
 - for understandings of the time scales - 1,000-100,000 years
 - World Weather Watch: pressure, temperature, humidity, wind
 - Commercial aircraft observations
 - Satellite soundings
 - Satellite cloud motion winds
 - Earth radiation budget from satellites
 - Ocean surface temperature
 - Precipitation
 - Land temperature, soil moisture, surface albedo
 - Runoff from major rivers
 - CO₂, O₃, and aerosols

The NASA climate planning activity found it useful to define four categories of climate as follows:

- Climate A
 - the status of the current climate

- Climate B

- climate changes from one month to one decade
GOAL: to document and predict changes

- Climate C

- climate changes for a decade and longer
GOAL: to understand and observe the effects of the sun, volcanoes, clouds, ocean, and ice sheets

- Climate X

- changes due to man's activities. This includes the effects of CO₂ changes due to man, overgrazing, forest cutting, atmospheric particles, etc.

Table 1 shows the Climate B data requirements from the NASA plan. Table 2 is for Climate C and X. Table 3 gives a listing of some of the planned climate data to be prepared during the FGGE year. It is taken from the report of the JOC Princeton meeting in February 1978.

To decide on what data sets are needed, we need to analyze the types of data that may be of use in determining the necessary parameters. Figure 2 shows an example of the information flow of a number of data types in oceanography. When a requirement indicates a need for a one-week or one-month average, we must consider the data necessary to make (and perhaps to remake) the average, as well as the particular data composite itself.

There are also important data requirements for climate impact assessments, and for climate services. A number of these needs should be covered by other talks at this workshop.

Considerations to Promote Data Use

We are behind in our efforts to prepare climate data. So far as is possible, our plans to prepare or improve data should be modular so that the user can obtain early benefit from the projects.

In considering the organization of data sets, we should note that data may be so scattered that they are hard to locate. Thus a gathering effort may be needed for a particular type such as rainfall data. On the other hand, data is sometimes merged too much. If many types of data are merged, a user has to sort through all of the data in order to use any one type. The plans should also provide for ease of updating of the data.

Table 1
Climate B Requirements (NASA Plan, 1977)

	Parameter	Desired Accuracy	Base Requirement	Horizontal Resolution	Vertical Resolution	Temporal Resolution	Index No.
Weather Variables (• Basic FGGE Meas.)	• Temp. Profile	1°C	2°C	500 km	200 mb	12-24 Hrs.	1
	• Surface Pres.	1 mb	3 mb	500 km	—	12-24 Hrs.	2
	• Wind Velocity	3 m/sec	3 m/sec	500 km	200 mb	12-24 Hrs.	3
	• Sea Sfc. Temp.	0.2°C	1°C	500 km	—	3 Days	4
	• Humidity	7%	30%	500 km	400 mb	12-24 Hrs.	5
	Precipitation	10%	25%	500 km	—	12-24 Hrs.	6
	Clouds			100 km	—	1 Day	7*
	a. cloud cover	5%	20%				
	b. cloud top temp.	2°C	4°C				
	c. albedo	0.02	0.04				
	d. total liq. H ₂ O Content	10 mg/cm ²	50 mg/cm ²				
Ocean Parameters	Sea Sfc. Temp.	0.2°C	1°C	500 km	—	1 Month	4a
	Evaporation	10%	25%	500 km	—	1 Month	9
	Sfc. Sens. Heat Flux	10 W/m ²	25 W/m ²	500 km	—	1 Month	10
	Wind Stress	0.1 Dyne/cm ²	0.3 Dynes/cm ²	500 km	—	1 Month	11
Radiation Budget	Clouds (Effect on Radiation)			500 km		1 Month	7a
	a. cloud cover	5%	20%				
	b. cloud top temp.	2°C	4°C				
	c. albedo	0.02	0.04				
	d. total liq. H ₂ O Content	10 mg/cm ²	50 mg/cm ²				
	Regional Net Rad. Components	10 W/m ²	25 W/m ²	500 km	—	1 Month	16
	Eq.-Pole Grad.	2 W/m ²	4 W/m ²	1000 km	—	1 Month	17
	Sfc. Albedo	0.02	0.04	50 km	—	1 Month	18
	Sfc. Rad. Budget	10 W/m ²	25 W/m ²	500 km	—	1 Month	19
	Solar Constant	1.5 W/m ²	1.5 W/m ²	—	—	1 Day	20
	Solar UV Flux	10% per 50 Å Interval		—	—	1 Day	21
Land Hydrology and Vegetation	Precipitation	10%	25%	500 km	—	1 Month	6a
	Sfc. Albedo	0.02	0.04	500 km	—	1 Month	18a
	Sfc. Soil Moist.	0.05 gm H ₂ O/cc Soil	4 levels	500 km	—	1 Month	22
	Soil Moisture (Root Zone)	0.05 gm H ₂ O/cc Soil	4 levels	500 km	—	1 Month	23
	Vegetation Cover	5%	5%	500 km	—	1 Month	24
	Evapotranspiration	10%	25%	500 km	—	1 Month	25
	Plant Water Stress	4 levels/2 levels		500 km	—	1 Month	26
Cryosphere Parameters	Sea Ice (% Open Water)	3%	3%	50 km	—	3 Days	27
	Snow (% Coverage)	5%	5%	50 km	—	1 Week	28
	Snow (Water Content)	±1 cm	±3 cm	50 km	—	1 Week	29

*NOTE: Under "Weather Variables" (Index No. 7), histograms of all four cloud parameters will be generated for 100 km x 100 km boxes.

Table 2

Climate C & X Requirements (NASA Plan, 1977)

Parameter	Desired Accuracy	Base Requirement	Horizontal Resolution	Vertical Resolution	Temporal Resolution	Index No.
Ocean Parameters	Sea Sfc. Elevation	10 cm	Variable	(As Indicated)	1 Week	12
	Upper Ocean Heat Storage	1 KCal/cm ²	500 km	—	1 Month	13
	Temp. Profile	0.2°C	Variable	—	1 Month	14
	Velocity Profile	2 cm/sec (near sfc) 0.2 cm/sec (at depth)	Variable	—	1 Month	15
Cryosphere Parameters	Ice Sheet	10 cm	1-3 km	—	1 Year	30
	SFC. Elevation	50 m/yr	Point targets	—	1 Year	31
	Ice Sheet Horiz. Velocity	1 km	1-3 km	—	1 Year	32
	Ice Sheet Boundary	—	—	—	—	—
Variable Atmos. Composition	Solar UV Flux	10% per 50Å	Interval	—	1 Day	21a
	Stratos. Aerosol	0.002	250 km N-S	3 km	1 Month	33
	Opt. Depth	0.005	1000 km E-W	3 km	1 Month	34
	Tropos. Aerosol	0.005	500 km	3 km	1 Month	35
Reasonably Well-Mixed Tropospheric Gases (ground-based observations)	Opt. Depth Ozone	0.005	250 km N-S 1000 km E-W	3 km	1 Month	36
	Stratospheric H ₂ O	0.5 ppm	250 km N-S 1000 km E-W	3 km	1 Month	37
	N ₂ O	0.01 ppm	—	—	1 Year	38
	CO ₂	0.5 ppm	—	—	1 Year	39
	CFM's	0.03 ppb	—	—	1 Year	40
	CH ₄	0.05 ppm	—	—	1 Year	40

NOTE: All Climate B parameters are also required by Climate C & X.

Table 3
Specifications of the Level II-c Data

Data Type	Resolution		Accuracy
	Spatial	Temporal	
1. Radiation budget components	250 km	1 day	15Wm^{-2}
2. Surface albedo	200 km	1-5 days	0.02
3. Cloudiness			
- average visible and infrared radiation	100 km	1 hour	0.5°IR 64 levels visible
- histograms (visible and infrared)	250 km	3 hours	2°IR 16 levels visible
4. Ozone			
- total content	500 km (satellite data); station network	1 day	5% (surface data) 5-10% (satellite data)
- vertical distribution	500 km (satellite data); station network	1 day (satellite) at least 1 week (surface network)	5-10%
5. Precipitation (surface network)	250 km	1 day	50%
6. Rain rate over oceans (satellite data)	500 km	1 day	4 levels of* discrimination
7. Water run-off (Outflow of major rivers)	selected river basins	1 month	to be defined
8. Snow cover	200 km	1 week	yes/no
9. Snow depth	200 km	1 week	0.5 cm water equivalent
10. Sea ice (including concentration)	100 km	5-15 days	to be defined
11. Oceanographic Variables			

* Possible diurnal bias to be studied

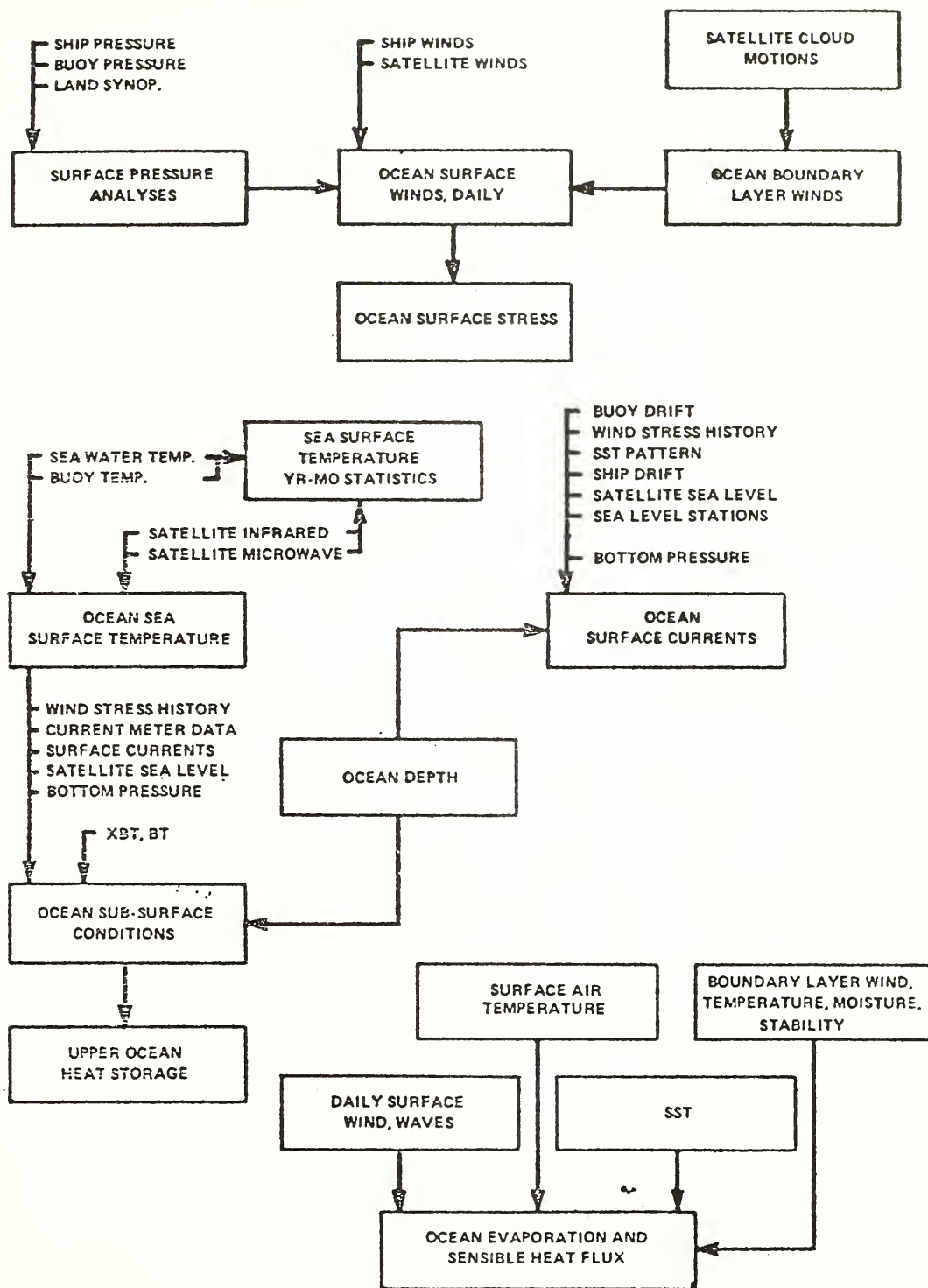


Figure 2. An example of the types of data that will be used to determine selected parameters in oceanography. Paleoclimatic data that gives information of past sea surface temperature and water level is also important but hasn't been included on this chart.

The data plans should give consideration to the possible need for improved calculations of analyses. This is often needed because analysis methods keep changing. Wherever there is a difficult transformation in a data path (such as an analysis or the calculation of rainfall from satellite radiance data), there should be an archive of both the input to the transformation, and the output.

Since there are many pitfalls in using climate data, we must be very careful to document changes in instruments, analysis methods, and station environments. We also need to document reporting changes such as a 16-point compass going to a 36-point compass far winds.

Instead of worrying very much about defining climate index values and standard averaging periods, we will prepare the basic data so that various choices are possible.

Quality control has long been a popular "buzz-word." It deserves further stress. It is important to make sure that the data sets are mechanically in good order. A user shouldn't have to struggle over incorrect data records, apparent unmarked duplicates that aren't equal, etc. We should concentrate on the more difficult checks such as reasonable time consistency of atmospheric pressure and ship location along ship tracks, etc. Data flags showing overall report status should be considered; these may carry messages such as "This raob still shows an unresolved inconsistency in the hydrostatic check, and it will be inspected later." We need to recognize that good data has been flagged as bad or thrown out in the past. Thus we should be cautious. Figure 3 shows a typical curve of useful output versus cost. It should be considered when planning the scope of data projects.

Most climate data sets have volumes that make them easy to deal with if they are once prepared in good order. However, some sets of high resolution data, such as selected satellite data, can tax our capabilities. For one global picture at the given resolutions, and a gray scale of 64 (6 bits per data point), the following data volumes and processing times may occur:

<u>RESOLUTION</u>	<u>BITS</u>	<u>TIME USING 10μs/SAMPLE</u>
100 km	.003 x 10 ⁸	.5 sec
10 km	.306 x 10 ⁸	51 sec
1 km	30.6 x 10 ⁸	1.4 hr
.1 km	3060. x 10 ⁸	142. hr

(A 1600 BPI tape holds 3 x 10⁸ bits.)

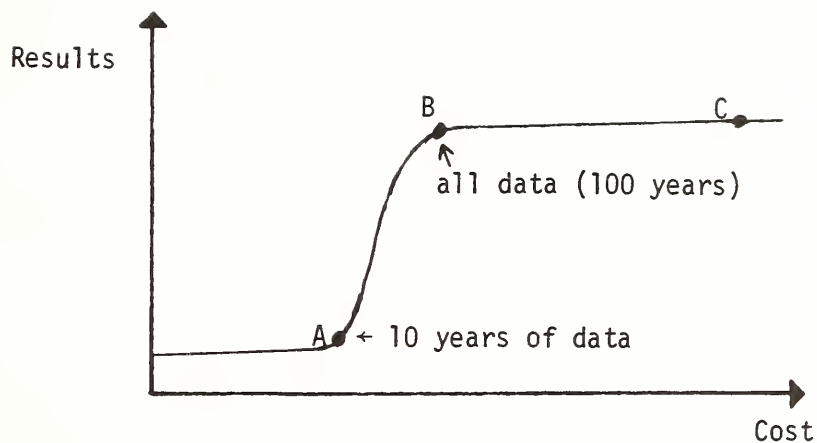


Figure 3. Example of a cost effectiveness curve showing the cost (A) of preparing 10 years of data and the cost (B) of preparing 100 years of clean data. Point (C) shows an extra effort that may have been too large to get every scrap of data and make it extra clean.

For climate purposes we should often consider data that are more averaged or synthesized than the original samples. This is especially important for high volume data. Examples of such data are:

- CO₂ MONTHLY MEANS
- AVERAGE RADIANCE EACH 3 DEGREES ALONG ORBITAL TRACK
- SELECTION OF BEST OR AVERAGED BEST CLEAR-COLUMN RADIANCE IN A 250-km AREA
- SELECT BEST SST RADIANCE IN AN AREA
- AREA AVERAGES AND HISTOGRAMS

<u>TYPE</u>	<u>RESOLUTION</u>	<u>BITS PER POINT</u>	<u>GRIDS PER DAY</u>	<u>BITS PER YEAR</u>
SPOT	1 km	8	72	25.4×10^{12}
AVERAGE	8	8	12	722.0×10^8
AVERAGE	100	8	36	12.7×10^8
IR HIST.	250	500	8 IR	25.3×10^8
VIS. HIST.	250	100	5 VIS	3.5×10^8

Some common "goofs" have been made in preparing data. These include:

- NO LOW VOLUME DATA SAVED
- LOW VOLUME DATA NOT SEPARATED FROM HIGH VOLUME DATA
- LOW VOLUME INPUT TO ANALYSES NOT SAVED AND ANALYSES SHOULD BE REDONE
- INPUT RADIANCES TO SHAKEY CALCULATIONS NOT SAVED:
SST RADIANCES NOT SAVED
MOISTURE CORRECTIONS NOT SAVED AND WERE BAD
- ONLY HIGH VOLUME AND VERY LOW VOLUME DATA SAVED
AN INTERMEDIATE VOLUME SET IS APPROPRIATE

In your deliberations on data set strategies in the different discipline areas, it may be useful to consider the following:

1. Organize basic data sets so that they are easy to use.
2. Prepare station library information, and information about analysis procedures.
3. Since we can respond quickly to small problems, concentrate on necessary data preparation that may involve long lead times or high costs. This includes cases where data are not digitized or not gathered.
4. Consider the problems with high data volume (hundreds or thousands of tapes.)
5. Consider methods to decrease costs.

This concludes my remarks.

REFERENCES

- Domestic Council, 1974: A United States climate program, a copy is maintained by NCPO, Rockville, Md., 39 p.
- ICAS, 1974: Report of the Ad Hoc panel on the present Inter-glacial, National Science Foundation, Washington, D.C., 22 p.
- ICAS, 1977: A United States climate program plan, ICAS (20 b - FY 1977), National Climate Program Office, Rockville, Md.
- Jenne, R. L., 1975: Data sets for meteorological research, NCAR. A global data base for climatic research. (In preparation) TN/IA-III, Boulder, Colorado, 194 p.
- National Academy of Sciences (NAS), 1978: Elements of the research strategy for the U.S. Climate Program,
- NASA, 1978: Candidate NASA data sets applicable to the Climate Program, GSFC. (Unpublished)
- NASA, 1977: Proposed NASA Contribution to the Climate Program, NASA, Goddard, Greenbelt, Md., 225 p.
- NCPO, 1979: National Climate Program, Preliminary Five-Year Plan, proof copy, May 11, National Climate Program Office, Rockville, Md., 148 p.
- NOAA, 1973: The influence of weather and climate on United States grain yields: Bumper crops or droughts, NOAA, Rockville, Md., 30 p.
- WMO-ICSU (JOC), 1976: The global data base for climatic research. Report of the JOC AD-HOC working group, GARP activities office, WMO-ICSU, Geneva, 39 p.
- WMO-ICSU, 1978: The Level II-C Data Management Plan, February Princeton Mtg., EC/IPF-VI/Dec. 7, JOC-WMO, Geneva,
- WMO-ICSU Joint Organizing Committee, 1975: The physical basis of climate and climate modeling. GARP Pub. Series No. 16, WMO, Geneva.

THE UNITED STATES DEPARTMENT OF AGRICULTURE
REQUIREMENTS FOR WEATHER (AND CLIMATE) DATA, SERVICE AND INFORMATION

Galen F. Hart, Chief
Research and Development Branch
Statistical Research Division
ESCS-USDA

SUMMARY

Background

At the direction of the Office of the Secretary an inter-agency committee of the Department of Agriculture prepared a report of requirements for weather and climate data and related services and information. This report:

- Consolidated and summarized specific requirements for weather data, service and information that reflect program needs by identifying specific data elements (variables) and services by the frequency of need.
- Recommended a means of coordinating weather requirements within USDA and between USDA-NOAA by establishing a coordinating committee and a Memorandum of Understanding between agencies to establish a close continuing and effective working relationship for developing detailed requirement specifications.

USDA requirements were categorized into four functional areas that reflect climate and weather service operations to assist USDA and NOAA in developing and implementing a program. These areas and their definitions were:

Climatological Services - acquisition, storage, management and summarization of atmospheric and weather data, including analyses of weather regimes and climate conditions.

Current Measurement and Observational Services - operation of acquisition programs and networks providing data on the state of the atmosphere.

Forecasting Services - prediction of future weather events or climatic conditions.

Other Services - consultation, advisory services, and interpretive activities.

This report was transmitted to NOAA Management in October of 1977.

Requirements Highlights

- The highest priority data elements for both current measurement and observational and climatological services were:
 - (1) Precipitation (total, intensity and duration)
 - (2) Air temperature (maximum - minimum, average)
 - (3) Snow (depth and water content)
 - (4) Wind (velocity and direction)
 - (5) Soil moisture (derived variable)
- Special Phenomena (intensity thunderstorm activity; occurrence such as a 30° drop in temperature in 30 minutes; hail size, amount and area affected; etc.) ranked below the above-mentioned data elements, but above many "standard" variables such as solar radiation, cloud cover and evapotranspiration. The frequency requirements for "special" "phenomena" observations would be on a daily basis as they occur.
- For forecast services, precipitation and temperature were the highest ranked data elements with special events (analogous to special phenomena) ranked third followed by the wind and snow elements.

The priority of data elements reflects the Department's primary concern with the assessment of weather (and climate) impact on all aspects of agriculture and forestry. Geographic coverage was not specified, but was defined generally as worldwide. Other specific characteristics of the weather requirements, e.g., accuracy or reliability, ease of recall from archives, etc., were heavily influenced by program application. Specific characteristics will need to be defined in continuing consultation as Departmental needs are defined.

Weather requirements of individual USDA agencies reflect the varied and diverse missions and programs in the Department. However, the committee reduced expressed needs to a basic set of data elements (variables), i.e., temperature, precipitation, radiation, which satisfy most Department needs. Differences between agencies were largely concerned with format, location, and time requirements, not the basic elements. Summarization of elements and setting of priorities for the Department was achieved by using self weighting quasi objective ratings made by individual agencies.

Plan of Implementation

A continuing activity will be required to satisfy the Department's weather data, service and information requirements. A broad Memorandum of Understanding has been established between USDA and NOAA.

Some of the principal activities to be addressed and their status are:

- The establishment of a historical data base, starting with 1931, on compatible USDA-NOAA equipment that will allow entry, transfer and output of data for the U.S. and major growing areas of the world. Status - no action to date.
- Expansion and improvement of forecast services and their delivery including probability forecasts and local "on-site" forecast support for special USDA programs. Status - good progress, USDA-NOAA Joint Agricultural Weather Facility (JAWF) established.
- The development of real-time capability to access current NOAA weather information for early warning of weather changes affecting production and quality of renewable resources. Status - in place via JAWF.
- Organization and expansion of the NOAA office located in USDA to provide quicker accessibility to the NOAA staff for the interpretation and understanding of current weather information and collection of special weather data, particularly for areas outside of the U.S. Status - in place via JAWF.

DISCUSSION OF DEPARTMENT REQUIREMENTS

General

The detailed requirements of individual agencies for weather data and information are quite variable. However, there is enough consistency in the general character to permit a grouping by element or atmospheric variable. The groups for four major classes of weather service function are further stratified by frequency with which the data are required, the time period over which the data are to be representative, and other major characteristics--for example, temperature: maximum or minimum; precipitation: duration, intensity, amount, etc.

The detailed tabular requirements are organized in order of priority (the most important requirement at the top of the table). Priorities were determined by a quasi objective scoring system in which each user agency rated the element according to a number of attributes determined by uses to be made of the data. The rating system was constructed to be self weighting so that scoring could be totaled to determine the Department rank or priority of the need.

Definition of Elements

The frequency requirement (6-hour, daily and longer period values) require the joint development of mutually satisfactory specifications.

A similar situation exists with respect to wind data. Specific applications of these data will require different smoothing and filtering practices. These will have to be developed on a case-by-case basis.

Other Services

There is a definite need for a broad range of special services which fall into the category of "other services." These needs include:

(1) Consultation Services

- Analysis of particular weather events in the major growing regions.
- Interpretation of current or recent weather events in terms of their abnormality.
- Interpretation of forecast materials.
- Monitoring and summarization of recent weather events in particular agricultural producing areas.

(2) Weather Briefings and Summaries

- Routine briefings with commodity and regional analysts to discuss weather events and potential impacts.
- Written summaries such as field station inputs to the Weekly Weather and Crop Bulletin.

(3) Special Studies and Analysis

- Determination of the number of selected weather events and their probability of occurring as an event or in combination with other factors.
- Assistance in developing methods of analysis for meteorological and climatological data.
- Development of historical series for such indices as the Crop Moisture and Palmer Indices.
- Extension of agrometeorological tools such as the Palmer Index, Crop Moisture Index and growing degree days to other parts of the world.

(4) User Education

- Develop materials, seminars and short courses to assist the Department in expanding its knowledge of weather

and its impact on agriculture. This would allow the Department to make better use of the information NOAA is providing.

Many of the services required involve USDA and NOAA working very closely, often on a one-to-one basis. The need for help will many times be on a demand basis, so the support must be readily accessible, preferably within the USDA complex.

PLAN OF IMPLEMENTATION

In order to effectively satisfy the identified requirements, plus additional requirements for research, a continuing activity must be established. To provide the mechanism for this activity, it was proposed that "A Memorandum of Understanding" and a Coordinating Committee be established between USDA and NOAA. This Committee would be made up of representatives from both USDA and NOAA under the chairmanship of the Director of Economics, Policy Analysis and Budget, USDA or his designee.

Following were some suggested guidelines (divided into the four service categories identified in this report) for developing the memorandum.

Climatological Services

The bulk of activities related to climatological services involve the establishment of one or more data bases which will satisfy the requirements for historical weather information. The development of such a system should include the following:

- (1) Establish jointly specified data files for monthly, weekly, or daily data.
- (2) Develop and store all data sets on equipment which is compatible between USDA and NOAA facilities to allow for the necessary entry, transfer and output of data. Both agencies would have the necessary software for accessing and updating data files.
- (3) Unless otherwise specified, the general period of record will be inclusive for the United States and cover the major growing areas of the world. As time and resources permit, however, this coverage should be expanded, particularly over the LDC's.
- (5) Mechanisms must be established for the delivery and dissemination of data when an agency does not have direct access to the files.

Current Measurements and Observational Services

Requirements for current information varied widely across the various agencies. The greatest demand is for daily and weekly information on both a national and international scale. However, as in the case of the Forest Service, the demand may be hourly or shorter in certain seasons, with very rapid delivery of the information.

A large portion of the information required is currently available directly from the National Weather Services' National Meteorological Center in Camp Springs, Maryland. Requirements for such operations as the Weekly Weather and Crop Bulletin are included under this category since the data are prepared and transmitted by the various forecast offices.

In order to satisfy these needs, the following guidelines may be appropriate:

- (1) Establish a mechanism for the real-time access of current information service to the USDA group requiring the information.
- (2) Incorporate the capability for both agencies to enter data with appropriate identifiers for extracting specific data sets.

Forecast Services

A large number of the requirements for forecast material are already being satisfied by NOAA. The general guidelines for this activity should include the following:

- (1) Continuation or expansion of current mechanisms for the delivery of forecast products to USDA.
- (2) Establish the mechanisms for providing updated or special forecasts.
- (3) Increase cooperation with such agencies as the Forest Service and Extension Service which requires current "on-site" forecast support.
- (4) Provide guidance in the preparation of probability forecasts when required.

Other Services

USDA requirements in this category cover a wide range of needs. Many of these services will require a close working relationship

between NOAA and USDA personnel. The need for assistance in this area will often be on a daily basis. This will require that NOAA personnel be readily accessible. It would appear that liaison groups of NOAA should be assigned to the Department of Agriculture to fulfill this need. This could be through an expansion of the current NOAA facilities located in USDA.

Categories of special services would include the following:

- (1) Special summaries using only data from the three above categories.
- (2) Those requiring analysis beyond simple summaries covered in (1) above.
- (3) Collection of special data on a reimbursable basis.

DATA ELEMENT (VARIABLE)	Frequency				
	Daily	7-10 day	Monthly	Season	Annual
Precipitation					
total	X	X	X	X	X
duration	X				
intensity	X				
Temperature, air, max-min and average	X	X	X	X	X
Snow					
depth	X	X	X		X
water content	X	X	X		X
Wind					
velocity	X	X	X		
direction	X	X	X		
Radiation, solar	X	X	X	X	X
Soil Moisture (derived variable)		X	X		
Temperature, soil		X	X	X	X
Special Phenomena					
thunderstorm activity					
lightning					
occurrence of extremes,					
precipitation					
frost					
temperatures over critical					
levels					
ice storms					
Cloud Cover	X	X	X		
Evaporation					
pan	X	X	X		
evapotranspiration	X	X	X	X	X
Temperature, dewpoint (humidity)	X	X	X		
Radiation, net	X	X	X		
Air Quality	X	X	X		
Visibility	X	X	X		

Development of both the historical data set and appropriate normals.

DATA ELEMENT (VARIABLE)	Frequency					
	Hourly	6-Hour	Daily	7-10 day	Month	Season
Precipitation						
total	X	X	X	X	X	X
intensity	X	X				
duration		X	X			
Temperature, air, max-min and average	X	X	X	X	X	X
Snow						
depth			X	X	X	
water content			X	X	X	
aerial coverage			X	X		
Wind						
velocity		X	X	X		
direction		X	X	X		
Soil Moisture (derived variable)			X	X		
Temperature, soil			X	X	X	
Cloud Cover		X	X	X	X	
Special Phenomena						
Radiation, solar			X	X	X	
Temperature, dewpoint (humidity)			X	X	X	
Evaporation						
pan			X	X		
evapotranspiration			X	X	X	
Air Quality		X	X			
Growing Degree Days (derived variable)				X	X	
Radiation, net			X	X	X	
Palmer Index (derived variable)				X	X	
Visibility			X	X		
Crop Moisture Index (derived variable)				X	X	
Heating Degree days (derived variable)				X	X	
Pressure						
surface		X	X		X	
upper air		X	X		X	

DATA ELEMENT (VARIABLE)	Frequency				
	Daily	7-10 day	Monthly	Season	Annual
Precipitation, total	X	X	X	X	X
Temperature, air, max-min and average	X	X	X	X	X
Special Events					
monsoon activity			X		
hurricane, typhoon			X		
blizzards, other severe weather			X		
Wind					
velocity	X		X	X	
direction	X		X	X	
Snow					
depth	X	X	X	X	
water content	X		X	X	
Temperature, dewpoint (humidity)	X	X			
Evaporation					
pan	X	X	X		
evapotranspiration	X		X	X	
Temperature, soil		X	X	X	X
Air Quality	X		X		
Cloud Cover	X	X	X	X	
Radiation, solar	X		X	X	
Visibility	X	X	X		
Radiation, net	X		X	X	
Pressure					
surface				X	X
upper air		X	X	X	X

ATTACHMENT I

RATING PROCEDURE FOR SETTING PRIORITIES DESCRIPTION OF RATING FACTORS

Agencies Requesting: Enter 1 for each variable requested by Agency. The USDA rating will be derived from agency ratings by Committee as follows:

1 or 2 agencies requesting	1
3 to 5 agencies requesting	2
More than 5 agencies requesting	3

Geographic area to be covered: To be assigned by agencies as follows:

Sub-U.S. regions	1
U.S.	2
Hemisphere or Worldwide	3

Frequency of Requirement Need: To be assigned by agency as follows:

Weekly or more frequently	3
Monthly	2
Semi-annually or annually	1

Importance of Variable or Service to Agency: To be assigned by agency as follows:

Most important variable for agency	5
Second most important variable for agency	4
Third most important variable for agency	3
Fourth most important variable for agency	2
All other variables	1

Impact on Food, Fiber or Forestry Production: To be assigned by agency as follows:

Minor	1
Intermediate	3
Major	5

Impact on Environment and Natural Resources: To be assigned by agency as follows:

Minor	1
Intermediate	3
Major	5

Total of all Ratings: To be obtained by summing all entries made by agency.

RATINGS FOR ESTABLISHING PRIORITIES FOR USDA WEATHER AND CLIMATE VARIABLES

Check one

- ☐ Current measurement or observation
☐ Forecast Service
☐ Climatological Services

(Agency)

Weather and climate variable or service	Agencies requesting	Geographic area to be covered	Frequency of requirement need	Importance of variable or service	Impact on food fiber, or for- estry production	Impact on en- vironment or natural resources	Total of all ratings
Temperature							
Air (Inc. M M)							
Soil							
Humidity							
Precipitation							
Snow							
Pressure							
Radiation							
Solar Net							
Cloud Cover							
Visibility							
Evaporation							
Air Quality							
Wind							
Anomalies (Thunderstorms, blizzards)							
Soil moisture							
Palmer Index							
Crop moisture index							
Heating degree days							
Growing degree days							

ATTACHMENT II

DEFINITIONS

Definitions of meteorological factors are based on the Glossary of Meteorology published by the American Meteorological Society, 1959. Exceptions are recent terms originating in environmental concerns and those terms referring to specialized agricultural applications.

- Air quality - As yet there is no generalized definition for air quality. In the absence of a standard definition, it is proposed that terminology used in U.S. Statutes and U.S. regulations be used where practical. The term includes both airborne particulates and gases originating in nature and through human actions.
- Air temperature - Measured according to existing standards (ongoing conversion to Celsius noted). Includes maximum and minimum measurements for specified periods, as well as means for period of interest.
- Anomalies - See "Special Phenomena."
- Cloud Cover - That portion of the sky cover which is attributable to clouds, usually measured in tenths of sky covered.
- Crop Moisture Index - A product of the Palmer Index calculations, this index is a measure of the amounts of moisture available to support crop growth and development.
- Evaporation - The physical process by which a liquid is transformed to a gaseous state. Usually direct measurement is by means of standard evaporation pan; however, other types of measurements are not excluded.
- Growing Degree Days - A biological transformation relating temperature to crop growth and development. May be based on different critical temperatures appropriate to the crop of concern.
- Heating Degree Days - A measure of heating fuel consumption based on the difference in daily mean temperature from 65°F.
- Humidity - A measure of the water vapor content of air. Unless otherwise specified, absolute humidity or vapor pressure is desired.
- Net Radiation - A measure of the energy remaining in a layer, normally just above the plant canopy when all fluxes of energy through the layer are considered in total.

- Palmer Drought Index - An index which measures the water balance of an area and evaluates the overall moisture situation to climatological normals.
- Precipitation - Any or all of the forms of water particles whether liquid or solid, that fall from the atmosphere and reach the ground. Measured according to existing standards. Includes rainfall, snow, hail and other forms. Reporting format will vary with the specific requirement, but will include means and cumulative data.
- Soil Moisture - Moisture in the rooting zone of the soil. This is typically the first 4 to 6 feet of the soil profile.
- Soil Temperature - Temperature of the soil at varying depth depending upon the specific application.
- Solar Radiation - The total electromagnetic radiation emitted by the sun which reaches the Earth's surface. Measured in langleys according to standard procedures, specifically the radiation reaching a horizontal surface from the sun (direct solar radiation).
- Special Phenomena - The description or measurement of specific events which are not measured by standard procedures.
- Visibility - The greatest distance in a given direction in which it is just possible to see and identify with the unaided eye (a) in the day time, a prominent dark object against the sky at the horizon, and (b) at night, a known preferably unfocused, moderately intense light source.
- Wind - Air in motion relative to the surface of the Earth; the terms refer to the horizontal component.

INTERAGENCY AGREEMENT

BETWEEN THE

U.S. Department of Commerce

AND THE

U.S. Department of Agriculture (USDA)

I. General Information

WHEREAS, the Department of Commerce, through the National Oceanic and Atmospheric Administration, has responsibility within the Federal Government for the monitoring and reporting of weather conditions, the forecasting of weather, the issuance of storm warnings, and the collection and dissemination of global weather information, and the distribution of meteorological and climatological information of interest to agriculture; and

WHEREAS, the Department of Agriculture has responsibility within the Federal Government to acquire, analyze and interpret information for the purpose of assessing the impacts on national and international food supplies, and to provide appropriate information related to the impacts of weather and climate on agricultural production to the people of the United States;

NOW, THEREFORE, the Department of Commerce and the Department of Agriculture enter into this interagency agreement to cooperate in the application of weather and climate information to requirements of agricultural policy planners and producers, and in the issuance of certain specialized weather, crop, and soil publications.

II. References and Authorities

Commerce enters into this agreement pursuant to the authority vested in it by 15 U.S.C. 313; Agriculture enters into this agreement pursuant to the authority vested in it by 7 U.S.C. 2201. This agreement supersedes all previous agreements between the two Departments relating to coordination and cooperation in climate and weather matters.

III. Purpose

The purpose of this agreement is to provide a framework for all cooperative efforts to meet the weather and climate information needs of the Department of Agriculture and the agricultural community. As appropriate, subsidiary agreements will provide

details on specific collaborative activities. When such agreements are developed they will become addenda to this master agreement. These subsidiary agreements will cover activities such as:

- providing weather data, interpretation and briefings, and climatic data and information, to Federal agriculture decision makers in USDA headquarters;
- joint editing and publishing the Weekly Weather and Crop Bulletin;
- cooperating in the execution of the National Agricultural Weather Service Program, in particular the making and disseminating to agricultural producers relevant weather observations and specialized agricultural weather forecasts and advisories;
- developing and testing weather/crop-yield models;
- providing climatic summaries for County Soil Surveys and other USDA publications;
- participating in cooperative regional research projects and other agrometeorological research;

IV. Definitions

For the purpose of this agreement, analysis refers to products expressed in meteorological or other geophysical units, while assessment refers to evaluation expressed in agricultural or economic units.

V. Responsibilities of the Departments

Commerce, NOAA is responsible for preparing and making available meteorological and climatic analyses, summaries, forecasts and outlooks. Agriculture is responsible for economic and operational assessments, and for assisting in dissemination and application of NOAA-prepared agricultural weather information. Details concerning these responsibilities, and joint publication activities, will be set out in subsidiary agreements.

VI. Programming, Budgeting, Funding and Reimbursement Arrangements

Within the terms of this agreement, budgeting, funding and reimbursements will be accomplished by the respective Departments in accordance with arrangement details established in subsidiary agreements. The expenses of the cooperating Departments shall be limited to those necessary to perform the activities stated above.

VII. Procedures for Review and Amendment

The activities under this agreement and its subsidiary agreements shall be jointly reviewed at least annually by appropriate policy-level officials such as the NOAA Assistant Administrator for Oceanic and Atmospheric Services and the USDA Director of Economics, Policy Analysis and Budget, and such changes as amendments to operating procedures that are required will be developed and implemented at that time.

VIII. Publications

The results of these cooperative activities may be published jointly or by either of the Departments separately. Manuscripts resulting from these activities should be submitted to the other Department for suggestions and approval prior to publication.

IX. Publication Affairs/Press Liaison

Data and information shall be released simultaneously by both Departments or with concurrence by the other when a release is by one Department.

X. Subsidiary Agreements

Additional working agreements between the Departments covering areas in paragraph III shall be effected in writing and become addenda to this agreement.

XI. Third Party Liability

Each Department will be responsible for processing any claims arising out of the negligent or wrongful acts of omissions of its employees.

XII. Amendments and Review

This agreement may be amended by writing at any time by the mutual consent of the Departments concerned. This agreement will be reviewed periodically but not less than annually and may be subject to reconsideration at such times as may be required and as agreed to by the parties entering into the agreement. Each Department agrees that prior to major changes in policy, budgets, or procedural practices affecting this or subsidiary agreements, such information will be communicated to the other Department.

XIII. Other Provisions

Nothing herein is intended to conflict with current Commerce or Agriculture directives. If the terms of this agreement are inconsistent with existing directives of either of the Departments

U.S. DEPARTMENT OF COMMERCE

USES AND SOURCES OF CLIMATE DATA AND
INFORMATION IN THE DEPARTMENT OF COMMERCE

Joshua Z. Holland
Director, Center for Environmental Assessment Services
Environmental Data and Information Service
Office of Oceanic and Atmospheric Services
National Oceanic and Atmospheric Administration

An outline of an Oral Presentation delivered at the
Climate Data Management Workshop follows.

-
1. Agencies and activities within the Department which are users, producers or managers of climate data and information.
 2. Examples of climate data and information products.
 3. Requirements for climate data and information.
-

Agencies and activities within the Department of Commerce which are users, producers, or managers of climate data and information.

	<u>Code</u>	
	<u>Known</u>	<u>Suspected or Potential</u>
User	<u>U</u>	(U)
Producer	<u>P</u>	(P)
Manager	<u>M</u>	(M)

U.S. Department of Commerce

National Oceanic and Atmospheric Administration	U	P	M
Industry and Trade Administration	(U)		
U.S. Travel Service	U		
National Telecommunications and Information Administration	U		
Maritime Administration	U		

U.S. Department of Commerce (Continued)

Economic Development Administration	<u>U</u>	
Assistant Secretary for Science & Technology		
National Bureau of Standards	<u>U</u>	<u>P</u>
Patent and Trademark Office	<u>U</u>	
National Technical Information Service		<u>M</u>
Chief Economist		
Bureau of the Census	<u>U</u>	
Bureau of Economic Analysis	<u>U</u>	

U.S. Department of Commerce
National Oceanic and Atmospheric Administration

National Climate Program Office			<u>M</u>
National Marine Fisheries Service	<u>U</u>	<u>P</u>	
Office of Coastal Zone Management	<u>U</u>		
Office of Research and Development	<u>U</u>	<u>P</u>	<u>M</u>
Office of Oceanic & Atmospheric Services	<u>U</u>	<u>P</u>	<u>M</u>

NOAA
National Marine Fisheries Service

Office of Resource Conservation and Management	<u>U</u>	
Office of International Fisheries Affairs	(U)	
Office of Science and Environment	<u>U</u>	
Office of Marine Mammals & Endangered Species	<u>U</u>	
Office of Habitat Protection	<u>U</u>	
Five Regions	<u>U</u>	
Four Fisheries Centers	<u>U</u>	<u>P</u>

NOAA
Office of Coastal Zone Management

Sanctuary Program Office	<u>U</u>
Resource Use Assessment and Coordination Office	<u>U</u>

Office of Research and Development

$$\frac{\frac{U}{U} \frac{P}{P}}{\frac{U}{U} \frac{P}{P}} M$$

Office of Research and Development
Environmental Research Laboratories

$$\begin{array}{ccc} \underline{\text{U}} & \underline{\text{P}} & \\ \underline{\text{U}} & \underline{\text{P}} & \\ \underline{\text{U}} & \underline{\text{P}} & (\text{M}) \\ & \underline{\text{P}} & \end{array}$$

$$\begin{array}{ccc} \underline{\text{U}} & \underline{\text{P}} & \underline{\text{M}} \\ \underline{\text{U}} & \underline{\text{P}} & \\ \underline{\text{U}} & \underline{\text{P}} & \\ \underline{\text{U}} & \underline{\text{P}} & \\ \underline{\text{U}} & \underline{\text{P}} & \underline{\text{M}} \\ \underline{\text{U}} & \underline{\text{P}} & \\ \underline{\text{U}} & \underline{\text{P}} & \underline{\text{M}} \\ \underline{\text{U}} & \underline{\text{P}} & \underline{\text{M}} \\ \underline{\text{U}} & \underline{\text{P}} & \underline{\text{M}} \\ & \underline{\text{P}} & (\text{M}) \end{array}$$

Office of Oceanic and Atmospheric Services

$$\begin{array}{ccc} \frac{U}{U} & \frac{P}{P} & \frac{M}{M} \\ \frac{U}{U} & \frac{P}{P} & M \end{array}$$

NOAA
Office of Oceanic and Atmospheric Services
National Weather Service

Office of Meteorology and Oceanography
Office of Hydrology
National Meteorological Center
Systems Development Office
Six Regions

U P
U P
U P
U P
U P

NOAA
Office of Oceanic and Atmospheric Services
National Ocean Survey

National Geodetic Survey
Office of Oceanography
Office of Marine Surveys and Maps
Office of Aeronautical Charting and Cartography
Office of Marine Technology
Office of Fleet Operations

P
U P M
U P M
P
P
U P

NOAA
Office of Oceanic and Atmospheric Services
Environmental Data and Information Service

National Climatic Center
National Oceanographic Data Center
National Geophysical and Solar-Terrestrial
Data Center
Environmental Science Information Center
Center for Environmental Assessment Services

U P M
U M
P M
M
U P M

Examples of Climate Data and Information
Products Available from NOAA

Examples of Climate Data and Information Products
from
Environmental Data and Information Service, NOAA

Basic weather and climate products

Local Climatological Data
Climatological Data - National Summary
Climatological Data
Comparative Climatic Data
Monthly Climatic Data for the World
Daily Northern Hemisphere Data Tabulations
Daily Series Synoptic Weather Maps Northern Hemisphere
Sea-Level and 500-millibar Charts
Storm Data
High Altitude Meteorological Data
Global Monitoring of the Environment for Selected
Atmospheric Constituents
State, Regional, and National Monthly and Seasonal Heating
Degree Days Weighted by Population
Environmental Satellite Imagery
Global Daily Max/Min Temperatures and Weekly, Monthly Summary*
Global Daily, Weekly, Monthly Precipitation*
Global Daily, Weekly, Monthly Snow Depth*
SOLRAD Data**

Crops and weather, precipitation, and drought

Weekly Weather and Crop Bulletin
Major Abnormal Conditions Affecting World Agriculture
Palmer Drought Index
Hourly Precipitation Data

Marine weather

Mariners' Weather Log
Marine Climatological Summaries

Miscellaneous products

Solar Terrestrial Physics and Meteorology - A Working
Document
NOAA Scientific and Technical Publications Announcement
Environmental/Resource Assessment and Information
EDIS Magazine

*"NOAA Products and Services of the National Weather Service,
National Environmental Satellite Service, Environmental Data and
Information Service, and the Environmental Research Laboratories,"
NOAA, Rockville, Maryland, 1977.

**Not in Catalog.

Examples of Climate Data and Information Products
from
National Weather Service, NOAA

Observed data without analysis

24-hr precip amounts
Winds aloft chart
Observed snow cover chart
Max and min temperature chart

Surface (sea level) data with analysis

North American surface analysis
Northern Hemisphere surface analysis
Tropical surface analysis
12-hr mean sea-level pressure change analysis
Radar analysis (MKC)
Weather depiction analysis
Degree-day charts

Upper air analysis

NWP upper air analysis
MIA upper air analysis
Stability index - moisture chart

Public Weather Service and Emergency Warnings

World Weather Watch participation
Temperature and precip tables
Road condition report
Winter sport area report
Daily weather maps
Severe weather statement
Storm report
Tropical cyclone position estimate

Surface long-range forecasts

Average Monthly Weather Outlook
Average Seasonal Temperature Outlook

Aviation Weather

In-flight reports from pilots
Aviation weather publications
Weather support for transportation safety hearings,
litigations, investigations

Examples of Climate Data and Information Products
from
National Weather Service, NOAA (Continued)

Marine Weather

Great Lakes Weather Observations
Great Lakes Weather Synopsis
Great Lakes Ice Program

Agricultural Weather Service

NWS/USDA Agricultural Weather Observations
30-Day Agricultural Weather Outlook
90-Day Outlook
Environmental Study Service Centers

Fire Weather

Extended Fire Weather Outlook
Annual Summary of the Fire Season

Air Pollution

Air Stagnation Narratives
Air Stagnation Data

Hydrology

Water Supply Forecast for Western United States
Headwater statement
Flood Potential Outlook
Water Supply Outlook
Greatest Known Areal Storm Rainfall Depths for Contiguous U.S.
5 to 60 Minutes Precipitation Frequency for Eastern and
Central U.S.
Precipitation-Frequency Atlas of the Western U.S.
Meteorological Criteria for Extreme Floods, Probable
Maximum Precipitation, Extreme rainfall and flood case
studies for various watersheds
Storm Tide Frequency Analysis for various coastal areas
Precipitable Water Over the U.S.
Some Climatological Characteristics of Hurricanes and
Tropical Storms, Gulf and East Coasts
Hydrometeorological data tapes for modelling
Hydrologic modes1
Snow Research Data

Examples of Climate Data and Information Products
from
National Environmental Satellite Service, NOAA

Image products

Geostationary satellites
 Full-disk and sector displays
 Direct readout and GOES-Tap
 Movie loops
U.S. Cloud Cover Depiction

Polar-orbiting satellites
 Stretched, gridded pass-by-pass SR images
 SR hemispheric polar-stereographic mosaics
SR polar-stereographic quadrant mosaics
SR Mercator mosaics
VHRR basic images
10-day minimum composite brightness

Meteorological products

Satellite winds: low-, middle-, and high-level cloud
 motion vector field messages
Atmospheric soundings (VTPR)
Weather summary and bulletins
 Satellite interpretation message
 Satellite weather bulletin
 Tropical disturbance summary
Two-layer moisture analysis
Satellite Input to Numerical Analysis and Prediction

Hydrological products

Basin snow cover observations
Northern Hemisphere Snow and Ice Chart

Oceanographic products

Sea Surface Temperature products
 Global operational SST observations
 Great Lakes surface temperature analysis
Ice charts and ocean current analyses
 Great Lakes and Alaskan ice charts
 Gulf Stream Wall bulletin
 West Coast thermal front analysis

Examples of Climate Data and Information Products
from
Environmental Research Laboratories, NOAA

Atmospheric Data

Global Atmospheric Carbon Dioxide Data
Ozone Data for the World
Geophysical Monitoring for Climatic Change
Annual Summary Report
Data Sets on Selected Hurricanes and Tropical Disturbances
Obtained by Specially Instrumented Research Aircraft
Data Sets for Severe Local Storm Weather Situations

Solar Data

Preliminary Report and Forecast of Solar Geophysical Data
Preliminary Report of Solar and Geophysical Activity
(Joint with USAF GWC)
Solar-Geophysical Indices
Solar-Geophysical Data

Scientific and Technical Publications of the Environmental
Research Laboratories

U.S. DEPARTMENT OF COMMERCE

REQUIREMENTS FOR CLIMATE DATA AND INFORMATION

USES IN DOC:

CURRENT AWARENESS, DIAGNOSIS
AND PREDICTION OF CLIMATIC
FLUCTUATIONS

VALIDATION OF CLIMATE MODELS

DETERMINATION OF INADVERTENT
CLIMATE MODIFICATION

MODELLING AND ASSESSMENT OF
CLIMATIC IMPACTS IN DOC
MISSION AREAS AND IMPACT
ASSESSMENT SERVICES TO OTHER
AGENCIES

ESTABLISHMENT OF DESIGN
CRITERIA AND STANDARDS FOR
EQUIPMENT AND FACILITIES

REQUIRE ALL TYPES:

BASIC ATMOSPHERIC DATA

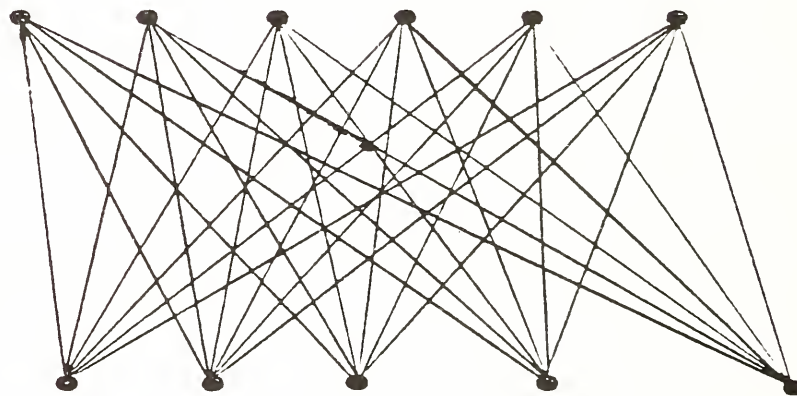
HYDROLOGY, PRECIP, ICE AND SNOW

OCEAN DATA

RADIATION, PHYSICS & CHEMISTRY

PROXY AND NON-INSTRUMENTAL

GEOGRAPHICAL, LAND USE & DATA
FOR ASSESSMENTS



Notes on the "Requirements" Diagram

Each of the six "data types" contains many sub-types. The pre-workshop survey yielded descriptions of more than 800 different data sets.

Each of the five "uses" represents many "users" working on different time-space scales, regions, applications.

Interconnections of specific data types with specific data users are more numerous than shown, by several orders of magnitude. The National Climatic Center, holding only a fraction of the data sets, responds to 70,000 data requests and distributes 1 1/2 million publications per year.

The pathways from producer to user, including processing steps and storage stops along the way, are the subject matter of "climate data management."

Summary

1. Qualitatively it is clear that the Department needs essentially all types of climate data and information and, in most cases, could benefit tangibly from improvements in accuracy and space-time coverage.
2. Quantitative requirements, in terms of time-space coverage and accuracy for each parameter, have been defined for some data types and uses, but remain to be defined for many others.
3. An efficient management system will be required to get the many types of climate data and information from producers to users in appropriate form and in a timely and economical manner.
4. The Department has, within the Environmental Data and Information Service of NOAA, some of the elements of such a system in place and others under development. We welcome the joint efforts with other agencies under the leadership of the National Climate Program Office to plan and implement a national program to meet present and future needs.

UNITED STATES AIR FORCE
ENVIRONMENTAL TECHNICAL APPLICATIONS CENTER

Elbert W. Friday, Director
Environmental and Life Sciences
Department of Defense

USAFETAC is a named Air Force organization assigned to Headquarters Air Force Global Weather Central (AFCWC), a unit of the Air Weather Service under the Military Airlift Command. The Center's mission is first to provide, within allocated resources, assessments and advice through tailored studies on environmental problems to the Air Force, Army, and other agencies as directed. Secondly, USAFETAC is to provide the capability to receive, store, retrieve, and process environmental data necessary to support customer requirements. This unit is comprised of 142 authorized personnel (120 Military) at Scott AFB and 85 personnel (all civilians) at Asheville, North Carolina.

The majority of USAFETAC's project work is descriptive. The Center is organized into six branches at Scott AFB plus an operating location at Asheville, North Carolina. The operations and administrative branches perform traditional support duties of these functions. The Aerospace Sciences Branch has the responsibility of evaluating, developing and adapting models, techniques, and data bases necessary to solve customer requests. Some of this branch's work includes climate prediction investigation, review of electro-magnetic propagation problems caused by atmospheric variations, investigation of probabilistic and statistical techniques and models to provide decision assistance, weather simulation efforts using such recently developed techniques as a dynamic cloud-free-line-of-sight model, and problems relating to future data requirements plus the testing of the present data sets. The Global Environmental Applications Branch has the primary responsibility for a major portion of the Center's customer consultations. In this branch, the models and techniques developed by the Aerospace Sciences Branch, as well as other sources, are adapted to answer questions on such areas as, but not limited to, atmospheric refractivity, upper air winds application, air quality assessments of air pollution, mixing heights and stability classes studies, engineering design criteria for the tri-services, operational decision assistance information, weather analysis to assist estimates of crop production (in the USSR and Peoples' Republic of China) and tailored support to on-going special programs. The Center's Climatological Services Branch provides data and technical information retrieval services, as well as editorial and cartographic support for both internal requirements and authorized outside customers. They maintain the Air Weather Service Technical Library and have a secure drop on the DDC Automated Information Retrieval System. The Automation Branch performs systems and applications programming as well as processing and monitoring of

certain portions of the Center's data base. The Scott AFB locations's automation resources include an in-house IBM 360/44 and a PDP 11/45, plus the use of several remote computers on the Defense Advanced Research Project Agency Network (DARPA NET). The Center's operating location (OL-A) at Asheville is co-located with the National Climatic Center (NCC). OL-A provides the handling of large data sets including the preparation and processing of standardized climatic summaries using a UNIVAC 1100/10. The unit is responsible for managing and maintaining the data base, including all data restoration. OL-A receives 80,000 daily observations from over 9,000 locations worldwide after processing thru AFGWC and the Scott AFB location. In addition to surface data it is also responsible for processing and monitoring several large gridded data sets of upper air variables.

USAFETAC's workload is driven entirely by requests from authorized customers (see Attachment 2). After a request is in-processed by the Operations Branch, an initial cost estimate is made and forwarded to the Center's Project Management Group (PMG). This group is composed of the Command Section and all the branch chiefs (except Administration) and it reviews new requests to bring corporate memory into effective use and to ensure that the Center takes an appropriate, efficient course of action on each and every request. The PMG assigns resources to a project and reviews active projects to pinpoint and correct problem areas. After a request has been reviewed by the PMG, it is assigned to a project manager. The project manager is the single point of contact for this project although it may require inputs from several areas of the organization. The analyst may use several techniques to satisfy the request such as consultation with the customer, library research for applicable information, a model or technique, programming, and/or computer processing. A project may require a report before final transmission. If so, the Center's editorial and/or cartographic sections will assist the project manager. The project and/or report is reviewed at the section and branch level for technical content prior to shipment to the customer. After the customer has received a USAFETAC project, he has the opportunity to provide the Center with his evaluation, including cost savings of the product.

USAFETAC's Climatic Data Management role is to receive, process, and store worldwide data from multiple sources. This global data base is required in order to produce the wide variety of customer requested assistance. The Center expends approximately 30 percent of its direct support resources in the production and retention of the data base. The primary data sets that presently reside at USAFETAC are:

- a. Data Save (DATSAV) files which contain worldwide standard surface and upper air station observations. These data are collected by the Automated Weather Network and comprise observations

from all WMO members including military participants. Then the data are sent via high speed circuits to AFGWC. It is processed at AFGWC for real time applications and retained until the completion of a 24 hour cycle. The following day these observations are sent to USAFETAC via the DARPANET. the DATSAV data is then checked for potential errors and flagged as necessary. The data sets are then copied and mailed to OL-A for necessary quality control, corrections and storage.

b. The 3-Dimensional Nephanalysis (3DNEPH) data set which contains worldwide cloud information. This is a unique integration of surface observations, aircraft reports, upper air observations and satellite data into a single 15 level, worldwide gridded cloud analysis on a 25 nautical mile horizontal resolution. The cloud analysis includes information on cloud bases and tops, cloud coverage (total and by level), cloud types, and present weather for each point six times a day. The data set is produced by AFGWC and mailed to OL-A for processing and storage.

c. The Analysis Data Set (ADS) which is a re-formatted collection of gridded global data derived from AFGWC's course mesh (200NM resolution) 15 level constant pressure upper air analysis. This 00Z and 12Z data set is transmitted every other day from AFGWC. It consists of pressures, D values, temperatures, dew-point depressions, and u and v wind components of the upper atmosphere.

d. Summarized Analysis Data Set (SADS). SADS is a statistical summarized version of the ADS minus the pressure parameter. The data are stored by pressure level, but a vertical stack by grid is also available.

In addition to these, the Center possesses many other data sets which are not used as extensively as the primary ones. These data sets include:

a. Wind Tower data from the instrumented towers at Vandenburg AFB, Patrick AFB, and Edwards AFB. In addition to winds, this data set includes some temperature and dewpoint information from 6 to 300 feet above ground level. It is customer quality controlled and used primarily for tailored studies supporting programs at these locations.

b. The Snow Analysis Data, provides a single, daily analysis of snow age, snow depth, and snow depth climatology. This data set is the output of AFGWC's Snow Cover Analysis Model.

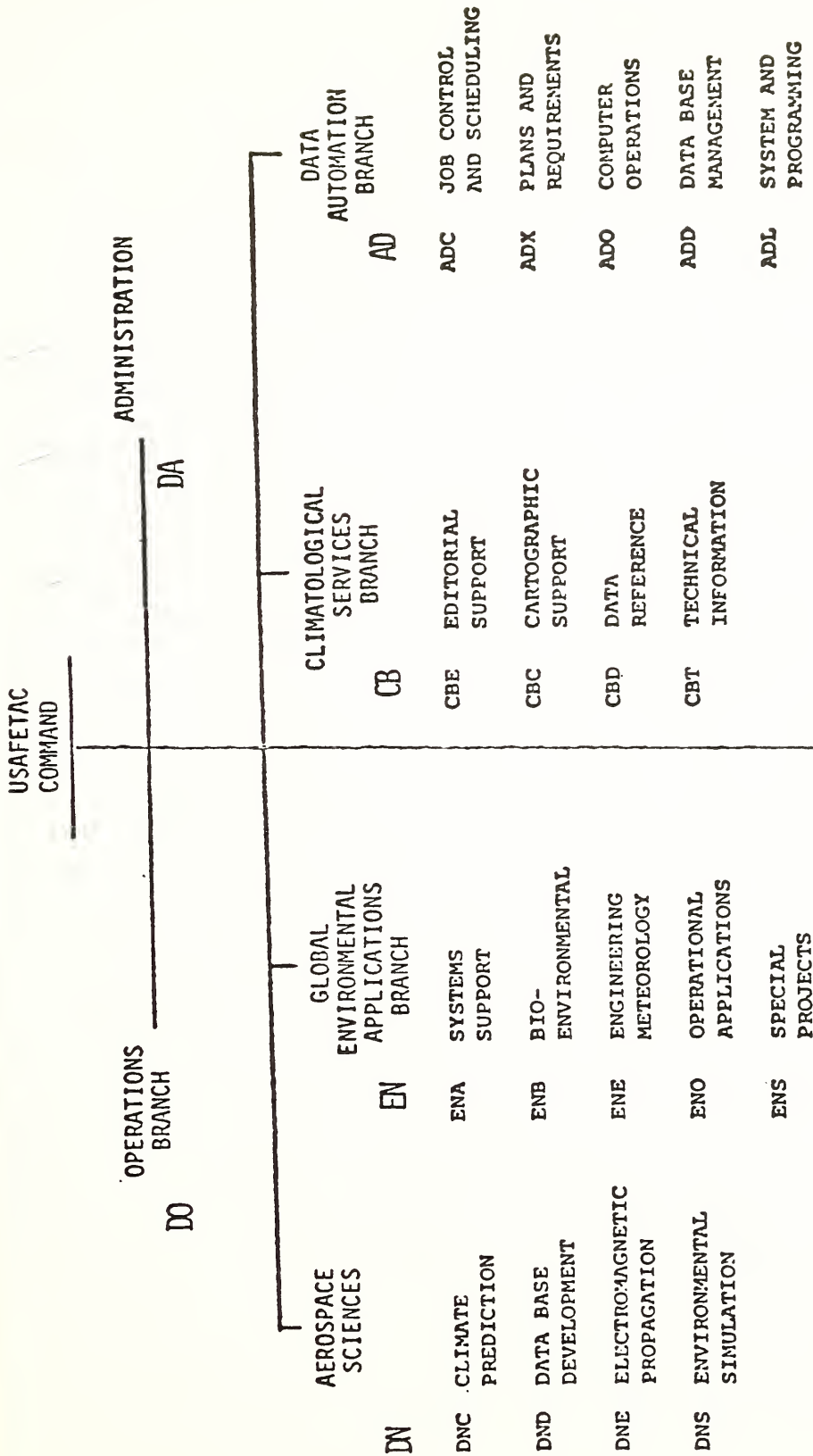
c. Period of record extracts for individual stations, both surface and upper air, are produced for applications work when required by the analyst for time periods of ten years or more.

d. The Terrain/Geography Data Set is derived from AFGWC's High Resolution Topography and Terrain Data Base. It is a world-wide gridded analysis of terrain height and geography set on the 3DNEPH grid system.

Presently, USAFETAC is initiating an aggressive data quality assurance program which provides both a subjective and a quantitative data analysis. Initiatives taken include a Problem Identification Program (PIP) for surface observations which flag possible data errors for future restoration by OL-A. The primary aspect of the PIP is utilization of the Station Data Information File (SDIF). The SDIF is a monthly, yearly, and a combined yearly set of climatological statistics which are used for incoming data comparison data. OL-A is the USAFETAC single manager for USAFETAC's data base. Also planned is the use of an upper air PIP for additional data quality assurance.

USAFETAC's future data base needs are only roughly known at this time. Increasing requirements for upper air studies and summaries will provide the opportunity to produce better and expanded atmospheric data sets. The increasing complexity of Air Force communications and weapons systems, especially in the electro-optical, infrared, and visual guided munitions, will increase the Center's need for improved tailored data sets. Finally, more and more emphasis today is being placed on the ability to simulate certain meteorological conditions, through actual or statistically generated data. Such simulation provides a technique for examining atmospheric processes and their effects upon modern weapons system. Data are currently being provided for simulator scenarios and some numerical simulation of atmospheric parameters is being done also, e.g., dynamic cloud-free-line-of-sight and wind factors. Expanded investigation of simulation techniques conditioned by real or synthetic data is envisioned for future customer support.

In summary, USAFETAC is involved in a wide variety of applied climatology to support DoD programs. It is engaged in techniques development and adaptation to ensure the latest products of the research community are available to the national security mission of DoD.

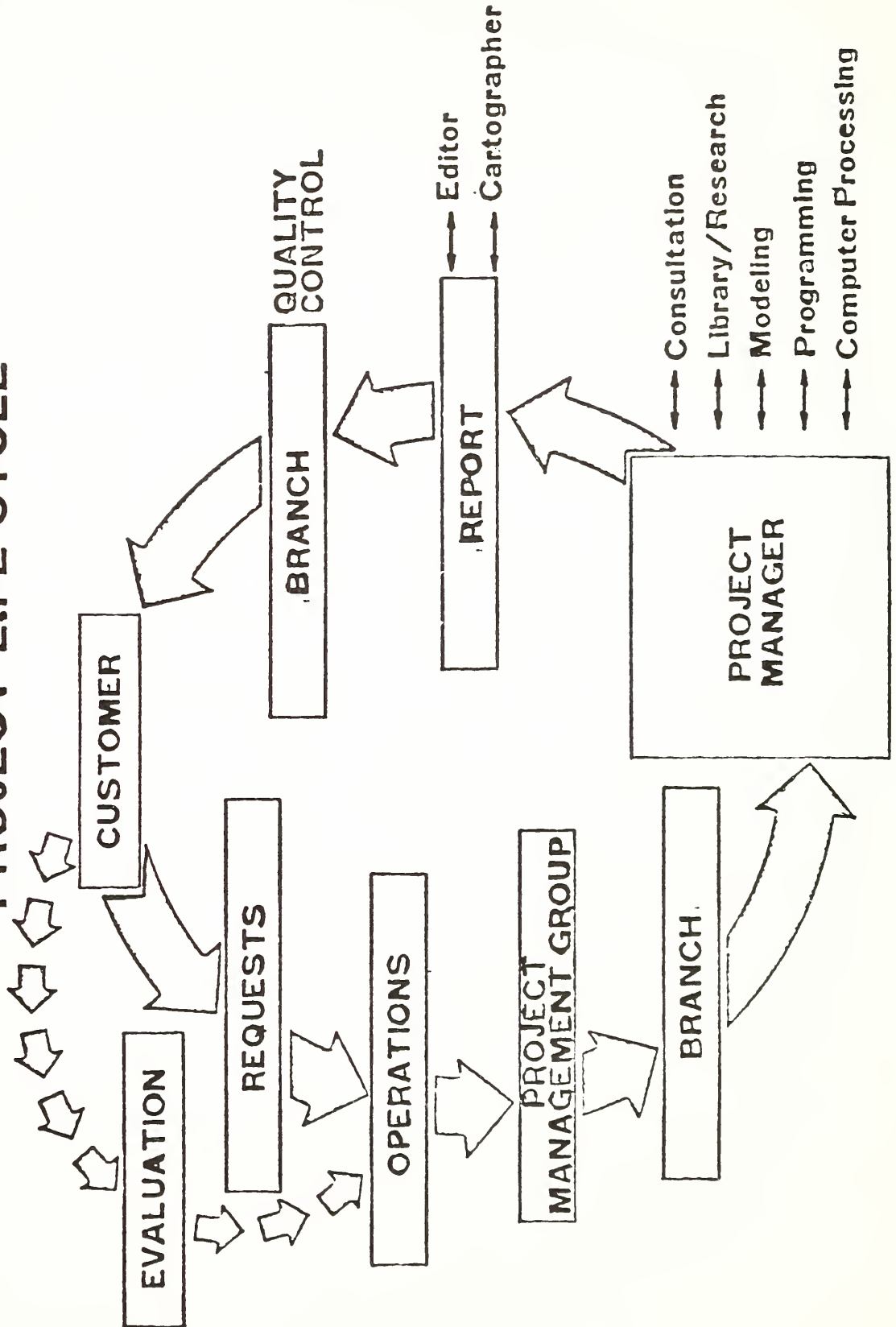


OPERATING LOCATION

ASHEVILLE, NC

OL-A

PROJECT LIFE CYCLE



CLIMATE DATA AND THE DEPARTMENT OF ENERGY

Harry Moses
Office of Environment
Carbon Dioxide and Climate Research Program

INTRODUCTION

The Department of Energy (DOE) is both a producer and user of climate data. Climate data are used to fulfill a variety of needs. Some of these are: (a) environmental monitoring; (b) decisionmaking during fuel emergency conditions; (c) forecasts for allocating fuels a month or more in advance; (d) operation of its large laboratories including the construction of new buildings; and (e) basic and applied research.

DATA SOURCES

The DOE laboratories are important sources for climate data. Data are generated from research programs such as the High Altitude Program in which aircraft and balloons are used to make stratospheric measurements. DOE has also supported data management activities to provide standardized formats for archiving data such as SOLMET (a format for hourly solar radiation data) or SOLDAY (a format for daily solar radiation data).

The wind characterization program also generates a considerable amount of wind data over the U.S.

Another valuable source of climate data stems from the measurements of DOE's Environmental Measurements Laboratory (formerly the Health and Safety Laboratory (HASL).) This group measures both radioactive and nonradioactive materials at the Earth's surface and in soils; it also participates substantially in the High Altitude Program. Table 1 shows the major sources of climate data generated by DOE.

A listing of the principal DOE laboratories which generate climate data is given in Table 2. As an example, the climate measurements made by the Atmospheric Physics Section of the Argonne National Laboratory is shown in Table 3. The Argonne National Laboratory, as well as a number of other DOE laboratories, have towers which support platforms for mounting meteorological equipment. These are used to measure the vertical profiles of meteorological variables of their variation with height. Such variables as wind direction, wind speed, or temperature are measured in this way. At Argonne

there is also a soil temperature system with measurements made at 1, 10, 20, 50, and 100 cm and also at 10 feet below the ground surface. For over 15 years, measurements were also made at 29 feet.

Conventional measurements taken are those of temperature, wind, humidity, surface atmospheric pressure, and solar radiation on a horizontal surface. Unconventional measurements are those of diffuse and normal incidence, solar radiation, air quality (ozone, sulfur, and turbidity), and rain chemistry. A number of DOE laboratories have fairly elaborate installations for taking climate data and have taken such data for several decades. For example, the Argonne meteorological measurements (though not all which are given in Table 3) were begun in 1949. Some of the DOE laboratories have even more elaborate meteorological stations, e.g., Brookhaven, Pacific Northwest, or Savannah River. The Office of Environment funds most of the climate data generated by the national laboratories.

Table 1. DEPARTMENT OF ENERGY

Climate Data Sources

1. DOE Laboratories
2. High Altitude Program
 - a. Project Airstream
 - b. Project Ash Can
3. SOLMET
4. Wind
5. Environmental Measurements Laboratory
6. CO₂ Program

Table 2. DOE LABORATORIES

Argonne National Laboratory - ANL
Brookhaven National Laboratory - BNL
Environmental Measurements Laboratory - EML
Idaho National Engineering Laboratory - INEL
Los Alamos Scientific Laboratory - LASL
Lawrence Berkeley Laboratory - LBL
Lawrence Livermore Laboratory - LLL
Nevada Test Site - NTS
Oak Ridge National Laboratory - ORNL
Pacific Northwest Laboratory - PNL
Sandia Laboratories - Sandia
Savannah River Laboratory - SRL
Solar Energy Research Institute - SERI

Table 3. ARGONNE NATIONAL LABORATORY
ATMOSPHERIC PHYSICS SECTION

Climatic Measurements

1. Vertical Profiles - 150 ft. tower
 - a. Wind speed
 - b. Wind direction
 - c. Temperature
 - d. Soil temperature - to 2- ft. below surface
2. Surface Measurements
 - a. Temperature
 - b. Relative humidity
 - c. Wind speed and direction
 - d. Precipitation
 - e. Station pressure
 - f. Solar radiation
 - 1) Direct (normal incidence)
 - 2) Diffuse
 - 3) Total on horizontal surface
3. Air Quality
 - a. O₃
 - b. S
 - c. Turbidity
4. Rain Chemistry

The DOE laboratories have been making measurements of climate variables which are unique. Some of these are shown in Table 4.

A source of unique data is the High Altitude Program. This program has two parts:

- Project Airstream

This project obtains measurements using aircraft. Flights are made three times a year in April, July, and October in the western hemisphere from the equator to 75°N and at elevations from 40 to 60 kft.

- Project Ash Can

This is a balloon sampling program. Balloon soundings are made three times per year in April, July, and October in New Mexico and only in April in Panama

and Alaska. Samples are taken in the stratosphere mainly from 70-90 kft. although at times data from greater elevations are obtained.

The High Altitude Sampling Program is designed to fulfill the following objectives:

- Document the concentrations of radioactivity, energy-related pollutants, and selected tracers in the stratosphere as a function of latitude, altitude, and season.
- Inventory the stratospheric burdens of these materials.
- Develop test and modify stratospheric transport models.
- Supply basic data for other scientific programs in studying the ultimate deposition of these materials in the environment and assessing their impact on health, environment, and climate.

Table 4. DEPARTMENT OF ENERGY

Special Measurements

1. Profiles of temperature
2. Profiles of wind speed and direction
3. Direct, diffuse, and spectral characteristics of solar radiation
4. Soil temperature
5. Rain chemistry - acid rain
6. High altitude climate measurements
7. Networks of profile measurements

- Maintain an early detection system for new or unusual stratospheric injections.
- Make available to the scientific community a unique stratospheric sampling system.

The Department of Energy is the lead agency for monitoring the increases of CO₂ in the atmosphere. It is carrying out a substantial program to assess CO₂ sources and sinks and to determine possible climate changes and the effects such changes would have on the environment and upon society. It is also

concerned with mitigating or corrective measures. In this connection in collaboration with the National Oceanic and Atmospheric Administration (NOAA), it is supporting a global network of about 20 stations including the well known station at Mauna Loa, Hawaii, to monitor concentrations of CO₂.

The Department of Energy is also supporting the Environmental Measurements Laboratory in carrying out measurements for acidity of precipitation at seven locations - Seattle, Washington; Beaverton, Oregon; Lawrence Livermore Laboratory, California; Argonne National Laboratory, Illinois; Chester, New Jersey; New York, New York; and Woods Hole, Massachusetts.

USERS OF CLIMATIC DATA IN THE DEPARTMENT OF ENERGY

There are many uses for climate data within the Department of Energy. Table 5 shows the major users of climate data within the Department.

A. The Energy Information Administration (EIA)

The Energy Emergency Information Management System (EEMIS) of EIA has a substantial need for climate data particularly heating and cooling degree days, temperature, and precipitation as well as climate forecasts a month or more in advance.

Table 5. DEPARTMENT OF ENERGY
USERS OF CLIMATE DATA

1. Energy Information Administration
Energy Emergency Management Information System
2. Economic Regulatory Administration
Energy Emergency Center
3. Federal Energy Regulatory Commission
4. Environmental Impact Statements
5. DOE Contractors
 - a. DOE laboratories
 - b. Universities
 - c. Others

The Energy Emergency Management Information System has the following objectives which may require climate data:

- To develop special information collection systems to be maintained on a standby basis for use during emergencies.

- To observe and estimate supply and demand conditions and establish indicators that signal the possibility of progression toward a critical energy emergency.
- To gather information on transportation system flexibility and availability of fuel substitutes in addition to basic supply/demand information in an energy emergency.
- To provide "core" energy emergency data around which states can build their own information response capabilities.
- To predict the effect of alternative emergency response measures.

To satisfy the above objectives in handling potential or actual emergency situations, climate data are needed. There are other objectives to this program which are not climate sensitive such as those involving protection for proprietary information or the provision of information exchange capability.

To satisfy the needs of EEMIS, a group within EIA has been at work in establishing a weather data base including information on heating degree days, cooling degree days, temperature and precipitation. Appropriate statistical operations such as averaging for suitable periods are performed to provide information needed to fulfill the above objectives.

Other groups within EIA also use climate data, particularly for analyzing fuel use-climate relations and for the preparation of Energy Data Bulletins.

B. The Economic Regulatory Administration (ERA)

The Energy Emergency Center of ERA works closely with EEMIS program personnel and makes use of the same climate data information. It also makes use of the 30-day and other long-range climate forecasts issued by the National Weather Service.

C. The Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC) has the need for climate data particularly precipitation and temperature or its derivative-degree days. This information is necessary for decisions dealing with fuel allocation. FERC receives on a regular basis from NOAA's Center for Environmental Assessment Services of the Environmental Data and Information Service population weighted heating degree day information for each week including departures from normal. Seasonal degree day data for the contiguous United States as well as comparisons with corresponding data of the previous year

in the form of ratios between consecutive years are presented. FERC also is routinely concerned with climate forecasts a season in advance. These are also furnished by the forecasters at NOAA and in some cases by others.

D. Environmental Impact Statements

In the preparation of Environmental Impact Statements a substantial amount of climate data must be used. These contain sections indicating the climate for the area and its impact on the proposed installation. Environmental Impact Statements contain data on wind speed and direction, frequency of extreme wind speeds, frequency of temperature extremes, thunderstorms and other climate data. Where toxic releases must be considered, then the statistical distributions of atmospheric stability or joint frequency distributions of wind speed and stability must be given.

E. DOE Laboratories

Not only are the DOE laboratories important sources for climate data, but also they make use of various types. These are either obtained on location or procured from other sources. Such information is used for research on such problems as wind power availability over the U.S. or in understanding the causes and processes which give rise to acid precipitation. Climate data such as soil temperatures are of vital importance in the construction of installations such as particle accelerators where foundation stability is essential.

F. DOE Contractors

Many different types of climatic data are used by universities or other institutions who have contracted to perform research or some other function to carry out one or more of DOE's missions. Examples are:

- MIT uses sea-surface temperatures to develop techniques for forecasting air temperatures 30 days or more in advance.
- At Colorado State University scientists are using climatic data to determine relations between fuel use and climate variables for different parts of the country and for population centers of different sizes.
- Scientists at the Aspen Institute for Humanistic Studies are using data on the variations in solar activity to ascertain possible effects as global climate.

The Office of Energy Research funds most of the climate work dealing with the upper atmosphere.

CONCLUDING COMMENTS

The above discussion shows that the Department of Energy is both a substantial user and producer of climate data. It must be pointed out that only the highlights are presented in this paper. The sources discussed are the major ones, but some have been omitted. Similarly, there are users of data in DOE which have not been mentioned.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance given by William Coblentz and Douglas Troop in providing information on the activities of the EIA; to Barry Yaffe and Henry Brooks for providing information concerning the EEMIS program; to John Moriarity and Chantell Haskins for information on the activities of FERC; and to Yvonne Allen and Alan Simmons for information on the Energy Emergency Center.

THE UNITED STATES DEPARTMENT OF THE INTERIOR
DATA USES AND NEEDS: NATURAL RESOURCES/LAND USE

An Outline of an Oral Presentation
delivered at the
Climate Data Management Workshop

George I. Smith
Coordinator of the USGS Climate Program

- A. Present responsibilities of USGS now focus on providing a reliable basis for:
 - 1. Identification of Nation's energy, mineral, water, and land resources.
 - 2. Policy and decision making by Federal, State, and local governments and the public concerned with these resources.
- B. Climate data uses and needs by USGS:
 - 1. About 50 percent of USGS "earth science" programs concern near-surface natural processes; data concerning climate are either required or generated as a by-product by many (most?) of these.
 - 2. Approximately 1,500 scientists are involved in studies related to present climate, past climates, or climate's effects on land and water resources.
 - 3. Estimated level of climate-related activities (FY78), \$6.9M.
 - 4. Level of identified USGS Climate Program (FY79), \$1.0M.
- C. Natural resource studies
 - a. Samples of concerns that involve climate:
 - 1. Mineral and energy resources
 - Environmental effects of mining and restoration
 - Regulation of exploration, development, production of Federal lands

- Radioactive waste disposal
- Nuclear reactor site safety
- 2. Water resources
 - Surface water studies
 - Ground water studies
 - Effects of water management strategies
 - Ground subsidence
 - Glacier-related hazards
- 3. Land resources
 - Erosion by water and wind
 - Burial by water - and wind - transported sediment
 - Avoidance of hazards related to climate
- 4. Avoidance of hazards related to climate

Examples of hazards:

- Floods
- Drought; effects on
 - vegetation
 - ground water
 - lake and river levels
 - subsidence of land surfaces
- Erosion by water
 - "normal" erosion
 - "badland" erosion
- Landslides, mudflows
- Coastal storm damage, including hurricanes
 - erosion
 - flooding

- Windstorms
 - erosion
 - redemption
- Reactor siting
 - regional hydrology patterns
 - subsidence or ground failure
- Radioactive waste disposal
 - changing water table
 - erosion

D. Land use studies

1. Generally need to understand relations between components of our ecosystem:

- Physical (geological) elements
- Biological elements
- Climatological elements

especially when natural equilibrium disturbed by man.

2. Need especially to protect fragile ecosystems

- deserts
- tundra
- estuaries
- prairies

3. Requirements

- Classification of Federal lands for mineral and mining potential
- Land use information
- Appraising Environmental Impact

Analyses of certain proposed projects

E. Production of climate-related data for research efforts

1. Data relating the impact of present or historical record on earth-surface processes
2. Paleoclimate data

Relation between 1 and 2:

-Present climate has one or more forms of impact on the present earth surface; past climates had similar and relatable impacts on the surface as it then existed, and that impact was imprinted on the geological record.

-Therefore, climatological data prior to times of the written record are in the "language" read by earth scientists.

-These are commonly called "proxy data."

Therefore, "proxy data" are indirect measures of one or more elements of past climate.

However, even though some consider "proxy data" to be of less value in a climate program, those earth science records commonly are DIRECT records of the very phenomena that would be of importance to man in the event of future climate change, i.e.

- floods
- erosion
- avalanches
- mudflows, etc.
- hurricanes
- droughts

PLEA

Manage climate data so that the information flow sheet can be turned upside down - so climate data can be converted to impact data. These are the kinds of information the USGS needs to discharge its obligations!

STATE CLIMATOLOGY

Some Remarks Concerning Climate Service Programs in the States and the Data Needs for These Programs

Wayne L. Decker
Department of Atmospheric Science
University of Missouri-Columbia

Under Section 6 of the National Climate Act, Intergovernmental Programs are authorized under the National Climate Program. These State programs will provide services concerning the use of climatic data. The data required must come from both the Federal networks and from specialized programs operated by the States. These data needs require special considerations for the accuracy, representativeness, and timeliness of the data. Listed below are some of these concerns.

On the following two pages are schematic diagrams to show the sources of data used in State programs and an organizational model for a typical State Climate Program.

Major Concerns for Climatic Data

1. Quality of Data (errors)
2. Density of Reporting Stations
3. Continuity of Reporting Stations
4. Representativeness of Data to the Application
5. Assessibility of Reports
6. Time Lag Between Observations and Published Reports

A major objective of the Intergovernmental Program of the NCP is to provide special studies and operational information for impacts of climate on agricultural production, energy supply and demand, and water resources. Using agriculture as an example, the following schematics show how agriculture interacts with climate.

The first figure portrays the importance of Institutional Resources in maximizing the use of natural resources and climatic resources. The second schematic is intended to show how agricultural decisions are made in terms of the uncertainty of weather or climate events. Each decision must be made by the producer with or without weather and climatic data. Climatic data can contribute to the selection of the most rational options.

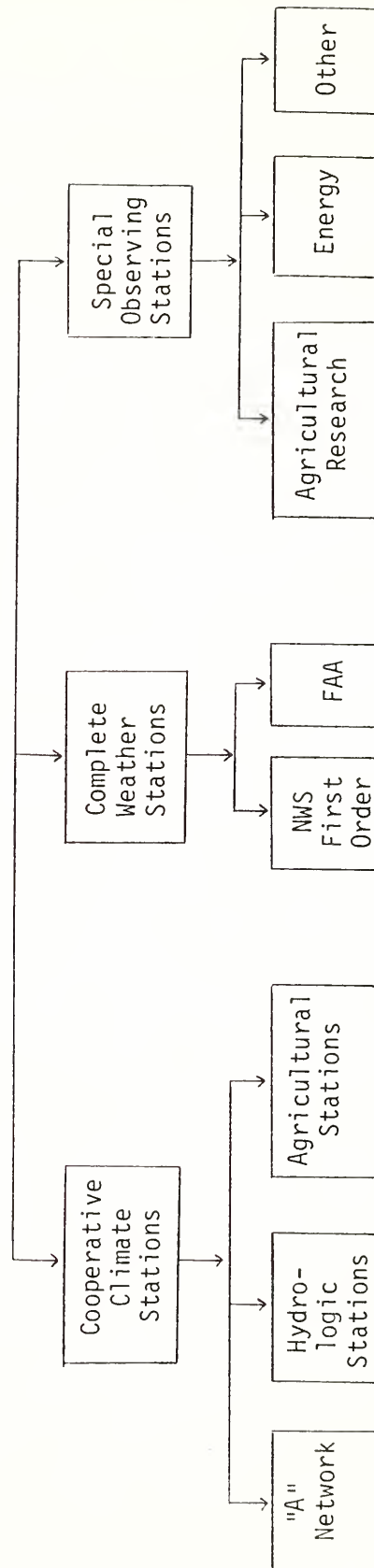


FIGURE 1. Climatic Data Sources.

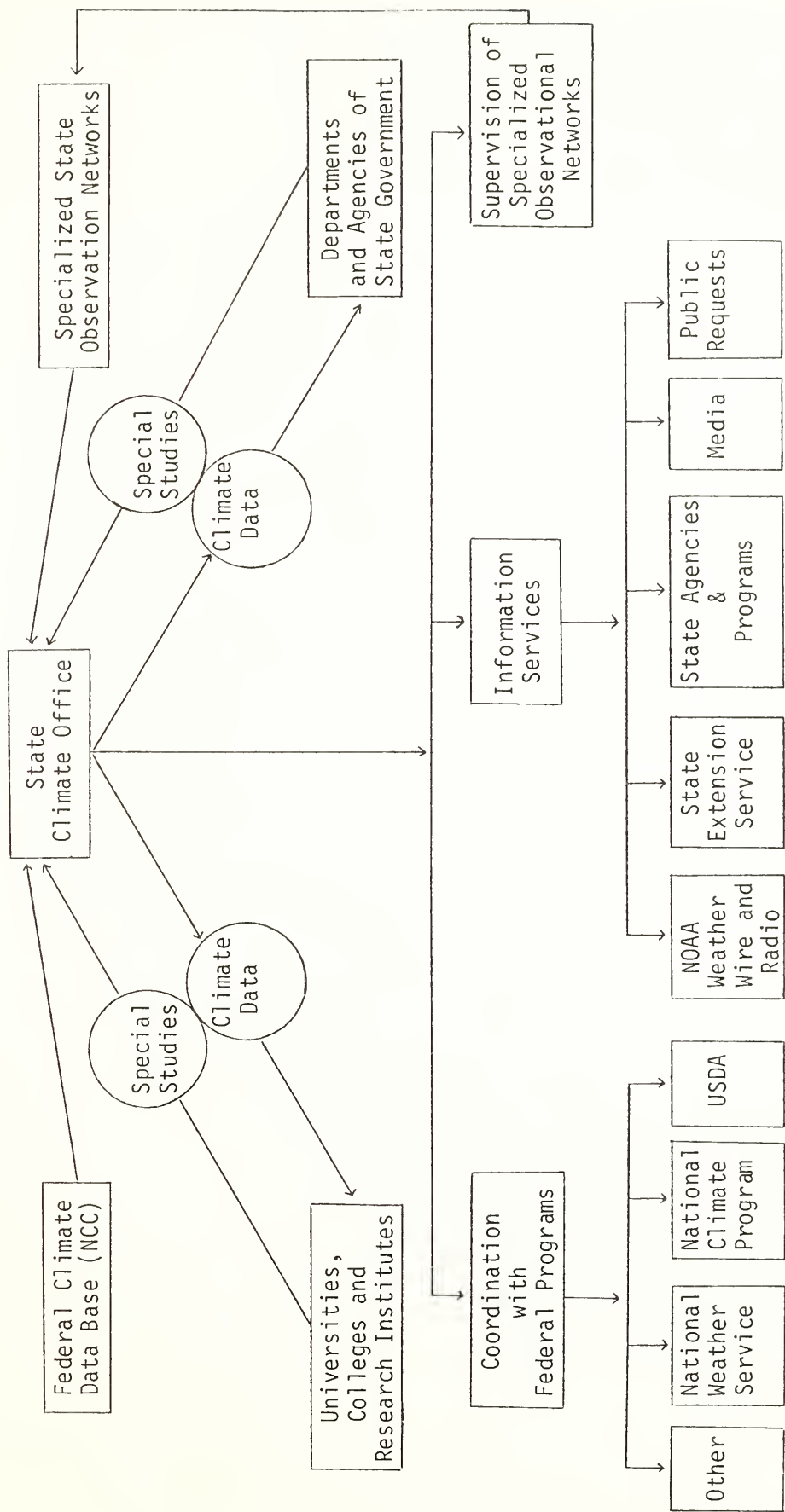


FIGURE 2. An Organizational Model for a State Climate Program under the Intergovernmental Program, NCP.

1. Special studies to define the sensitivities of the biological event to weather must be made. These results must quantify the return in profit or production from the selection of different options. The special studies require historical data concerning both the agricultural or biological event and climate.
2. The options must be selected by the producer in terms of the weather events that have occurred over the past season, or past few weeks, or (in some cases) over the past day or two. This requirement calls for timely data, sometimes in "real time."
3. An assessment of the probabilities of future weather events must be made. The base for these probability analyses is the historical climatic data.

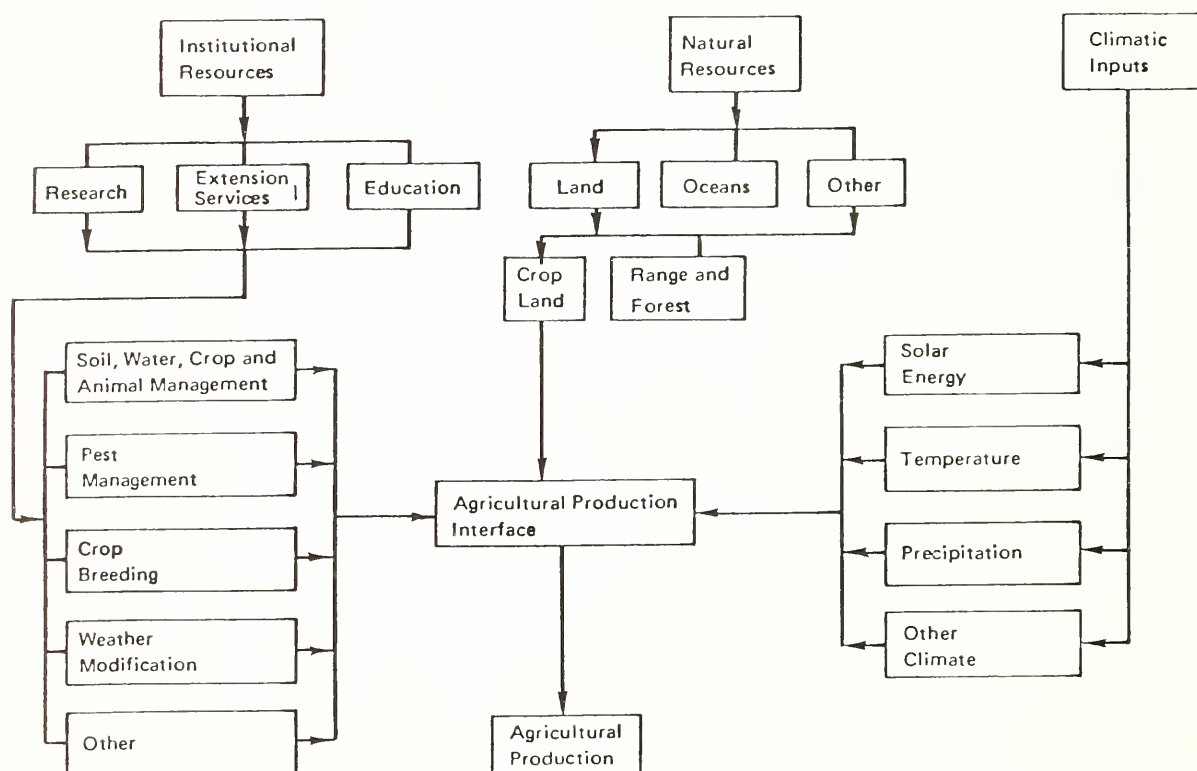


FIGURE 3. The interaction between Institutional Resource and natural resources (including climate) in providing for abundant and stable agricultural production. (From National Research Council Report, Climate and Food.)

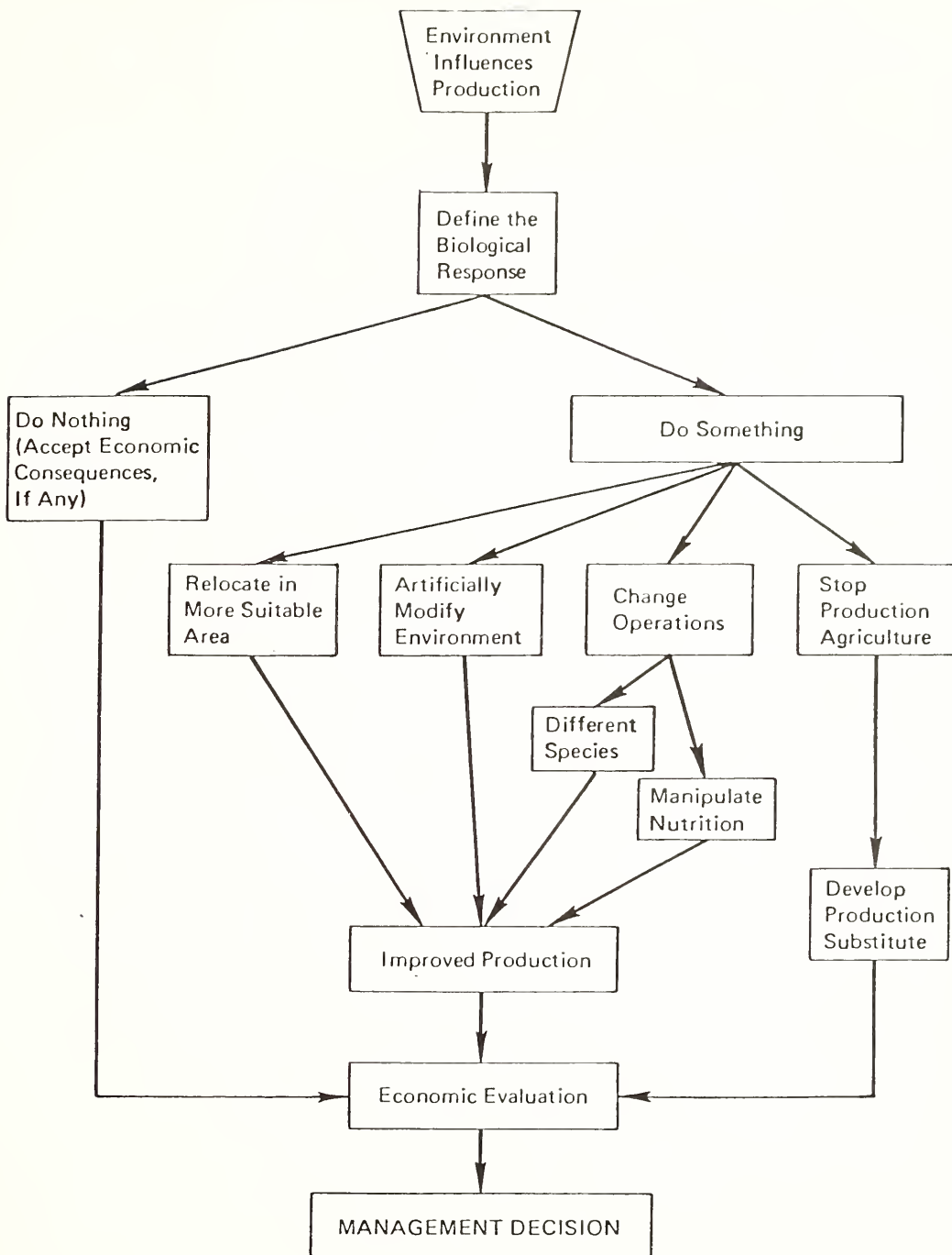


FIGURE 4. Diagram of the decisions made by agricultural producers in the face of variable and uncertain climatic events. (From National Research Council Report, Climate and Food.)

PRESENTATION ON THE SURVEY OF NASA DATA
ON POTENTIAL APPLICABILITY TO THE CLIMATE PROGRAM

Karen W. Posey
Information Extraction Division
NASA/Goddard Space Flight Center

The following information was presented at the Special Symposium on Data from Space Satellites by Ms. Posey who discussed the GSFC concept of the climate data management problem and the recent efforts of GSFC to compile information on NASA climate-related data. Copies of the preliminary working notes resulting from these efforts were distributed to all Working Group Chairmen.

SURVEY OF NASA DATA OF POTENTIAL APPLICABILITY
TO THE CLIMATE PROGRAM

OBJECTIVES

- IDENTIFY NASA DATA SOURCES OF POTENTIAL APPLICABILITY TO THE CLIMATE PROGRAM
- DETERMINE CHARACTERISTICS OF SELECTED DATA SETS
 - PARAMETERS MEASURED OR DERIVED
 - RESOLUTION, FREQUENCY, COVERAGE (SPATIAL & TEMPORAL)
 - QUALITY
 - DATA REDUCTION
 - MEDIUM, VOLUME
- SCOPE THE OVERALL CLIMATE DATA SET PREPARATION AND DATA MANAGEMENT PROBLEM

CURRENT STATUS

- WORKING NOTES COMPILED AND AVAILABLE (MAY 1978, APRIL 1979)
- CONTINUING TO UPDATE AND EXPAND

SURVEY OF NASA DATA OF POTENTIAL APPLICABILITY

TO THE CLIMATE PROGRAM

INFORMATION ACQUIRED FOR EACH INSTRUMENT SURVEYED

● **SCIENTIFIC OBJECTIVES**

● **INSTRUMENT CHARACTERISTICS**

- Frequency channels
- Measurement geometry (scan pattern, resolution; coverage)
- Data rates

● **DERIVED SCIENTIFIC PARAMETERS**

- Parameters
- Resolution, frequency, coverage (spatial & temporal)
- Quality
- Availability/accessibility

● **APPLICABILITY TO THE CLIMATE PROGRAM**

● **DATA PRODUCTS AND VOLUME**

- Key processing operations
- Standard products (medium, archive location)
- Volume

● **REFERENCES**

Parameter vs. Source Cross-Reference for Candidate NASA Data Sets

		Nimbus 4, 5, 6				AEM SEASAT		Nimbus G					AEM		SAS/GOES		
Parameter (Index No.)		HUV-4	LSMR-5	LSMR-6	LRD-6	TCMR	Altitude log	SMR	LRB	LINS	SAM II	SAMS	SBUV/TOMS	SMR	SAGE	VISSR	VAS
I	Sea Surface Temperature (4)							✓						✓			
	Sea Ice Concentration (27)		✓	✓				✓						✓			
	Snow Cover (28)			✓										✓			
II	Solar Constant (20)				✓				✓								
	Radiation Budget Parameters (16-19)				✓				✓								
	Ozone (35)	✓								✓			✓		✓		
	T.H Soundings (1 & 5)																✓
III	Stratospheric Aerosols (33)										✓				✓		
	Winds (Upper Air) (3)															✓	✓
	Winds (Ocean Surface) (11)			✓				✓						✓			
IV	Surface Albedo (18)				✓				✓							✓	✓
	Cloud Cover (7)															✓	✓
	Precipitation (6)		✓	✓				✓						✓		✓	✓
V	Cloud Top Temperature (7)															✓	✓
	Cloud Albedo (7)															✓	✓
	Total Liquid Water Content (7)			✓				✓						✓			
	Soil Moisture (22 & 23)			✓		✓								✓			
	Evapotranspiration (25)					✓											
	Plant Water Stress (26)					✓											
	Snow Water Content (29)			✓										✓			
	Sea Surface Elevation (12)							✓									
	Ice Sheet Surface Elevation (30)							✓									
	Solar UV Flux (21)	✓											✓				
	Stratospheric H ₂ O (36)									✓		✓	✓				
	NO ₂ (37)									✓							
	NO ₂ , X, O (37)											✓					
	CH ₄ (40)												✓				
VI	Thermal inertia					✓											
	Wave height, direction, length						✓										
	Stratospheric temperature									✓		✓					
	Mesospheric temperature											✓					
	Stratospheric HNO ₃									✓							
	Stratospheric & Mesospheric CO											✓					
	Total Atmospheric Water Vapor			✓				✓						✓			
	Land Surface Temperature													✓			
	Open Water (%) Over Land													✓			
	Sea Ice Surface Temperature													✓			
	Snow Surface Temperature													✓			
	Snow Sub-Surface Temperature													✓			
	Ice Sheet Surface Temperature													✓			
	Multi-Year Ice Fraction													✓			
	Thin First Year Ice Fraction													✓			

- I = Initial priority I parameter identified during the Climate Science Advisory Panel Meeting
- II = Initial Priority II parameter identified during the Climate Science Advisory Panel Meeting
- III = Initial priority III parameter identified during the Climate Science Advisory Panel Meeting
- IV = Initial additional parameter identified during the Climate Science Advisory Panel Meeting
- V = Identified in Proposed NASA Contribution to the Climate Program, not identified as an initial parameter during the Climate Science Advisory Panel Meeting
- VI = Not identified as a climate parameter in Proposed NASA Contribution to the Climate Program, but derivable from surveyed instruments

SURVEY OF NASA DATA OF POTENTIAL APPLICABILITY TO THE CLIMATE PROGRAM

ESTIMATED TAPE VOLUME ACCUMULATED BY 12/81 FOR SAMPLE NASA DATA SETS

SPACECRAFT	SENSOR	LEVEL 1 TAPES	LEVEL 11/111 PARAMETER TAPES	LEVEL 11/111 DISPLAY TAPES	PROJECTED COVERAGE
NIMBUS-4	BUV	260	60	-	4/70-10/77
NIMBUS-5	ESMR	650	30	260	12/72-5/77
NIMBUS-6	ERB	770	65	-	6/75-9/79
NIMBUS-6	ESMR	75	3	30	6/75-8/77
NIMBUS-7	ERB	550	80	40	10/78-10/81
	LIMS	210	120	40	10/78-'9/79
	SAM II	36	48	-	10/78-10/81
	SAMS	550	36	-	10/78-10/81
	SBUV/TOMS	240	510	200	10/78-10/81
	SMR	1000	470	110	10/78-10/81
AEM-2	SAGE	12	16	-	1/79-1/80
SMS-1 1-2/	VISSR	**Only a subset of Level I data archived at GSFC			
GOES-1, -2, 1-3		(65000 tapes as of 8/78)**			
TOTAL FOR SELECTED SAMPLE		10,850	1,450	680	

NOTE: DOES NOT INCLUDE LEVEL 0 DATA (175 to 750 TAPES PER YEAR PER INSTRUMENT) AND ALL NASA

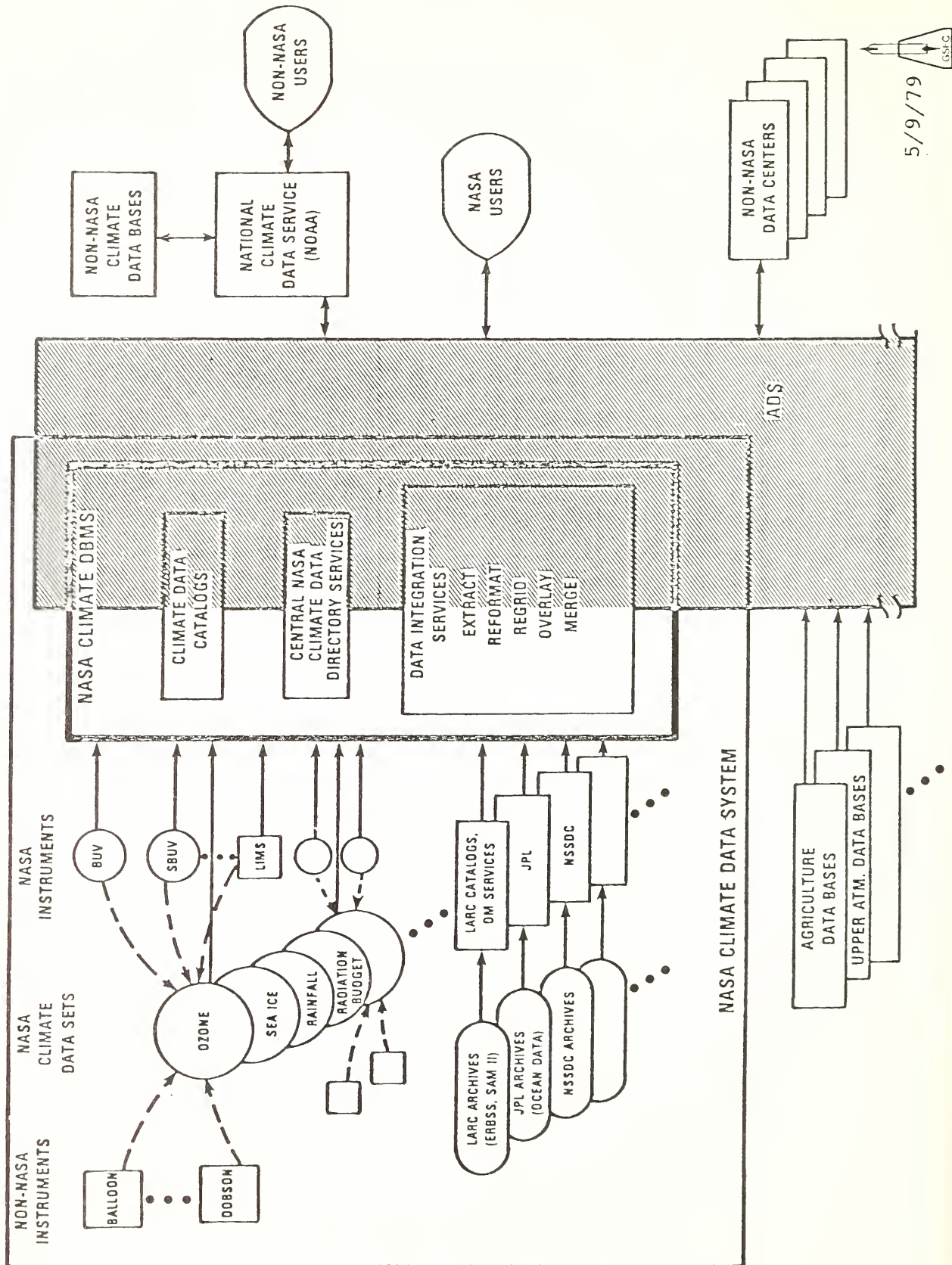
SOURCES (E.G., SEASAT, LANDSAT, GOES-D, NOAA, NIMBUS THIR)

SURVEY OF NASA DATA OF POTENTIAL APPLICABILITY TO THE CLIMATE PROGRAM

SAMPLE OF NUMBER OF DATA SETS CONTAINED
ON SMMR LEVEL II/III PARAMETER TAPES

Tape Description	Data Set Description	No. of Data Sets/Tape	No. of Tapes by 12/81	No. of Data Sets by 12/81
PARM-30	1 orbit of derived scientific parameters (= 1 file)	80	~ 180	14,400
PARM-LO	1 orbit of derived scientific parameters (= 1 file)	160	~ 90	14,400
PARM-SS	1 orbit of derived scientific parameters (= 1 file)	160	~ 90	14,400
MAP-30	N or S polar map (multiple maps per file)	20	36	720
MAP-SS	N or S polar map (multiple maps per file)	84	36	3,024
MAP-LO	Day or night imager map (multiple maps per file)	58	36	2,088
Total for Level II/III parameter tapes (factor of 100)			~ 470	49,032

GSFC CONCEPT OF NASA CLIMATE DATA SYSTEM AND APPLICATIONS DATA SERVICE INTERFACE



PENN STATE UNIVERSITY LIBRARIES



A000070940763

NOAA--S/T 79-266